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ЗА ПРИРОДНЕ НАУКЕ

MATICA SRPSKA
PROCEEDINGS FOR
NATURAL SCIENCES

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2006

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ОДЕЉЕЊЕ ЗА ПРИРОДНЕ НАУКЕ

ЗБОРНИК
МАТИЦЕ СРПСКЕ ЗА ПРИРОДНЕ НАУКЕ

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Učesnici IV Međunarodnog simpozijuma o zaštiti šećerne repe
Participants of the IV International symposium on sugar beet protections

INTRODUCTION

Department for Environmental and Plant Protection has a long lasting tradition in studies concerning sugar beet diseases, pests and weeds and measures of their control. The Department for Environmental and Plant Protection organized three very successful International Symposiums on Sugar Beet Protection. They were all held in Novi Sad: 1964 — 7 participating countries, 1966 — 17 participating countries, 1969 — 19 participating countries, as well as the II R B Scientific Meeting of the working group for sugar beet pest studies (Novi Sad, 1978).

In cooperation with Serbian Academy of Sciences and Arts, branch in Novi Sad, Research Institute for Field and Vegetable Crops, Novi Sad and Matica srpska, Novi Sad, the Department for Environmental and Plant protection of the Faculty of Agriculture, Novi Sad organized the IV International Symposium on Sugar beet Protection celebrating 45 years of its existence.

AMBITIONS OF THE SYMPOSIUM:

The exchange of scientific research results with European and world results.

The development of regional cooperation with the aim of joint effort concerning the Europian market.

The improvement of production technology for increased and stable crops of sugar beet.

Unification of all the subjects in sugar beet production — science, expertise, technology of sugar beet processing, chemical and seed companies, farmers.

Our wish is to make your participation in the symposium and stay in Novi Sad pleasent ones. Our aspirations are directed towards its outgrowth into a nourished tradition.

The expectations and ambitions of the organizers were accomplished since 53 lecturers from our country and 44 lecturers from 12 foreign countries were present. Within the fields of phytopathology, phytopharmacy, herbology and enthomology, 45 papers were presented. Foreign lecturers on request were from the USA (Barry Jacobsen, PhD, phytopathologist), Israel (Baruch Rubin, PhD, herbologist) and Ukraine (academician Vitaly Fedorenko, PhD, enthomologist and academician Mykola Royik, PhD, selectionist). Other participating countries were Greece, Hungary, the Czech Republic, Slovakia, Russia, Belorus, Moldavia, Romania and Serbia and Monte Negro. The Symposium was supported by the Ministry of Science and Environmental Protection, Ministry of Agriculture, Water economy and Forestry, Vojvodina Province Secretariat of Agriculture, Water economy and Forestry, Secretariat of Sience and Technological Development, as well as by Secretariat for Environmental Protection and Sustainable development. Chemical companies which supported the Symposium were Magan-Yu, BASF, Bayer Crop Science, Agrimatco group — Dipkom, VST trend, DELTA M, Syngenta, Hemovet, Galenika — phytopharmacy. Companies for seed production and distribution: Research Institute for Field and Vegetable Crops, Novi Sad, SES Vanderhave, Atel company, KWS, Lion seeds and sugar rafineries: MK group, stock company, sugar rafinery "Šajkaška" — Žabalj and stock company sugar rafinery Crvenka, insurance company DDOR Novi Sad and Media Zemun.

About 200 people from the field of science, profesion and sugar beet processing participated in the Symposium.

The official languages of the Symposium were English and Serbian.

President of the organizing committee
Doc. dr Vera Stojšin

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ROOT ROT DISEASES OF SUGAR BEET*

ABSTRACT: Root rot diseases of sugar beet caused by *Rhizoctonia solani* (AG 2-2 IIIB and AG 2-2 IV), *R. crocorum, Aphanomyces cochlioides, Phoma betae, Macrophomina phaeseolina, Fusarium oxysporum* f.sp. *radicis-betae, Pythium aphanidermatum, Phytophthora drechsleri, Rhizopus stolonifer, R. arrhizus* and *Sclerotium rolfsii* cause significant losses wherever sugar beets are grown. However, not all these soil-borne pathogens have been reported in all sugar beet production areas. Losses include reduced harvestable tonnage and reduced white sugar recovery. Many of these pathogens also cause post harvest losses in storage piles. Control for diseases caused by these pathogens include disease resistant cultivars, avoidance of stresses, cultural practices such as water management and the use of fungicides.

KEY WORDS: control, effects of environment, sugar beet, root rot diseases

RHIZOCTONIA CROWN AND ROOT ROT

Rhizoctonia crown and root rot caused by the fungus, *Rhizoctonia solani*, AG 2-2 intraspecific groups IIIB and IV (perfect stage, *Thanatephorus cucumeris*) causes one of the most damaging sugar beet diseases wherever sugar beets are grown. These fungi are considered common soil inhabitants (Windels et al., 1997). In the USA more than 24% of planted acres have economic damage from this disease while in Europe only 5—10% of planted acres are considered to have economic losses, although the incidence of this disease seems to be increasing (Büttner et al., 2003). Losses can range from negligible to more than 50%. Yield reductions result from loss of harvestable roots in the field, reduced tonnage due to decay of harvestable roots and from reduced white sugar recovery. Symptoms include a sudden and permanent wilting of leaves and a dark-brown to black discoloration of petiole bases. Taproot lesions are dark-brown to black in color and typically originate near the crown. Lesions are superficial and there is a sharp distinction between diseased and

* The paper was presented at the first scientific meeting IV INTERNATIONAL SYMPOSIUM ON SUGAR BEET Protection held from 26—28 september 2005 in Novi Sad.

health tissues. *Rhizoctonia* rotted roots are often cracked. In advanced stages, the entire root may rot leaving holes in the ground at harvest. While both *R. solani* intraspecific groups can also cause damping-off and crown and root rot of sugar beet and can attack both *Phaseolus* sp. and soybean, they differ in that AG 2-2 IIIB can attack wheat, maize, rice and matt rush and can grow at 35°C whereas AG 2-2 IV does not grow at 35°C and does not attack wheat or maize. Both intraspecific groups are found worldwide although AG 2-2 IIIB seems to be more common in Europe, particularly where sugar beets are rotated with maize. *Rhizoctonia solani* AG-4 causes damping-off for sugar beets, *Phaseolus* sp., alfalfa and soybeans. It is important to identify which AG group is prevalent in a production area so that appropriate rotations can be planned. Losses are highest in warm, irrigated production areas where sugar beets are cropped intensively. Occurrence is similar in dry land production, but chronically, wet areas are often most affected. Typically, damage occurs in patches where presumably populations of suppressive organisms are low relative to undamaged areas of fields. Our research and that of others clearly show that most infections occur through the crown from bulbils (sclerotia) deposited there during cultivation and by wind or water. Infection seems to be dependent on soil temperature with temperatures less than 15—20°C resulting in little disease development compared to temperatures of 24—35°C for AG 2-2 IV. Similar data is not available for AG 2-2 IIIB although observations suggest that this intraspecific group is damaging at higher temperatures than AG 2-2 IV.

While this disease occurs in all soil types, it is commonly most severe in heavy, poorly drained soils. Once soil populations of this fungus are built up, rotation is of little value and growers are dependent on relatively ineffective cultural controls such as early planting, avoiding cultivating soil into the row, maintaining adequate, balanced fertility for good crop growth and maintaining adequate soil drainage. Effects of nitrogen fertility have been reviewed by Rush and Winter (1990) and Elmer (1997). Elmer (1997) demonstrated that application of chloride salts reduce the disease on table beet. Where disease pressure is high, growers can plant specialty varieties with resistance. Available resistance is incomplete and these varieties typically have yield potentials 10—20% less than the best approved varieties, although newer varieties are only 0—10% lower yielding than the best approved varieties (Jacobsen et al., 2005). However, these varieties may not have other important disease resistant characteristics such as resistance to the *curly top* and *Rhizomania* viruses, *Fusarium yellows*, *Aphanomyces black root rot*, or *Cercospora leaf spot*. An alternative to the use of partially resistant varieties is the use of fungicides applied in furrow at planting, when plants have 4—8 leaves or when soil temperatures at the 10 cm level are greater than 20—24°C. In studies in Montana, optimal economic returns and disease control have been with susceptible varieties with fungicide application. The best partially resistant varieties have also shown yield responses to fungicide application but have never equaled the yield of susceptible varieties sprayed with fungicide.

Several fungicides have been shown to be useful in reducing disease incidence including TPTH, chlorothalonil, pencycuron, PCNB, tebuconazole, azoxystrobin, trifloxystrobin and pyraclastrobin. Of these, azoxystrobin has provided the most consistent level of control in both inoculated and natural infection trials (K i e w i c k et al., 2001; J a c o b s e n et al., 2005). Timing of application is critical, with fungicide deposition in the crown needed before infection occurs. Recent studies in Montana and in North Dakota have shown that application of azoxystrobin when the soil temperature at the 10 cm depth is in the 19—22°C range will provide good to excellent control while applications when the 10 cm soil temperature exceeds 24°C result in poor or no control.

VIOLET ROOT ROT

Violet root rot is caused by *Rhizoctonia crocorum* (*Pers.: Fr.*) *De Candolle* (perfect stage, *Helicobasidium brebissonii*) and has been observed sporadically throughout the western U.S. and Europe where sugar beet is grown. It is considered to be the most important disease of sugar beet in Spain. The fungus has been observed on other hosts nearly worldwide. Unlike *R. solani* AG 2-2, this fungus seems to be intimately associated with the roots of weed hosts such as white cockle (*Lynchnis alba* M i l l.), annual sowthistle (*Sonchus oleraceous* L.), common yarrow (*Achillea millefolium* L.), shepaherds purse (*Capsella bursa-pastoris (*L.), medic and common groundsel (*Senecio vulgaris* L.) (S c h n e i d e r and W h i t n e y, 1986).

Affected plants generally occur in localized, often circular patches. While wilting sometimes occurs, root symptoms are most characteristic. Roots initially have purple, reddish-purple spots with a similar felt like fungal growth that advances from the root tip to the crown. Roots shrivel and will have large amounts of soil associated with the root surface. Sclerotia are often found around secondary roots.

Specific control have not been developed and management involves rotations that avoid susceptible crops such as potato, sweet potato, carrot, asparagus, bean, cabbage, turnip, rape, oil seed radish, pea, clover, vetch and alfalfa and control of weed hosts. There are more than 160 plant species that are known hosts. Improved soil aeration is said to reduce disease severity. Early harvest may reduce losses.

APHANOMYCES BLACK ROOT

Aphanomyces black root has been reported from the sugar beet growing areas of the North Central and High Plains regions of the U.S., Canada, England, Europe, Chile and Japan. Losses can be 0—100% depending on environmental factors and the degree of soil infestation (W i n d e l s, 2000). In all areas, the disease occurs in two phases, acute seeding blight and chronic root rot. Infection and disease development requires warm (22—28°C), wet soils. Seedling damping-off is typically characterized initially by grayish, water-soaked hypocotyls lesions that eventually become black, constricting lesions near the soil line. These constricting lesions often extend up the hypocotyls causing the hypocotyls be black and threadlike. Plants often break off at the site of these lesions. Chronic root rot symptoms initially appear as yellowish-brown lesions that extend into the root interior. These lesions become dark-brown or black with time. The root may rot entirely, have only tip rot, or will have bark like scabby superficial lesions. Tip rots will often become dry and constrict the root. Above ground portions of the plant will exhibit wilt on hot, bright days, often with recovery at night. Leaves may show scorch type symptoms. While the disease can develop in soils of all textures, it is most common in heavy--textured soils that have a propensity to remain wet for extended periods.

This disease is caused by the oomycete, *Aphanomyces cochlioides* D r e s c h and survives as oospores (16—24 μm) in the soil. Large numbers of oospores are produced in rooted root tissues. The fungus is homothallic and a relatively small percentage of oospores will form sporangia at any given time. Recent studies have shown that some oospores are relatively short lived, however rotations are relatively ineffective because of the large numbers of oospores produced (D y e r et al., 2004). While oospores can directly infect roots, infection is more commonly the result of sporangia formation and release of zoospores (biflagellate, 7—11 μm). Sporangia formation and zoospore release is favored by temperatures in the 22—28°C range, by presence root exudates and by presence of free water. Secondary infections can occur from zoospores released by sporangia produced on the surface of diseased roots. *Aphanomyces cochlioides* can also cause disease on table beet, mangel, chard, spinach, *Chenopodium*, *Amaranthus* and *Beta* species. Weed species appear to contribute to the survival and increase of inoculum levels in soils where rotations are used. The pathogen is spread by anything that moves infested soil. Growers should avoid pacing tare soil back on production fields.

Black root is best controlled by implementation of an integrated management program that may include partially resistant varieties, seed treatment with hymexazole, early planting, enhanced soil drainage, control of *Chenopodium* and *Amaranthus* weed species, soil indexing (long rotations with non-host crops, use of oat green manures (W i n d e l s and B r a n t n e r, 2004) and application of industrial waste lime (W i n d e l s et al., 2004). While soil indexing to predict disease severity has limitations, it is useful in predicting the need for partially resistant varieties or avoiding planting fields with high root rot potential (W i n d e l s and N a b b e n - S c h i n d l e r, 1996). It is important to understand that in general the partially resistant varieties have a lower yield potential in the absence of disease than susceptible varieties and that severely infested fields can have non-economic yields if conditions favor disease despite implementation of the best integrated management program. The use of hymexazole plus bacterial biological seed treatments has shown promise in reducing *Aphanomyces black root* damage under moderate disease pressure. Because *Aphanomyces* infected roots have higher respiration and increased invert sugar levels, they deteriorate more rapidly in storage than healthy roots thus heavily infected lots should be processed as soon as possible (C a m p b e l l and K l o t z, 2005).

PHOMA ROOT ROT

Phoma root rot caused by *Phoma betae* (perfect stage, *Pleospora bjoerlingii*, Byford) has been reported in wherever sugar beets are grown in Asia, Australia, Europe and North America. The causal fungus can cause seedling damping-off, root rot and leaf spot in the field and decay in storage piles. Unless plants are stressed in the field, root rot is generally of little economic importance. Seedling damping-off results from planting infected seed. Root rot symptoms in the field include wilting of foliage and the occurrence of small, dark-brown, sunken lesions with a watery rot near the crown. Decay spreads inward with the decayed area typically becoming dark-brown to black with prominent black lines. Later, rotted areas become coal-black, dry and shriveled. Bolting beets are most likely to be killed. *Phoma rot* in storage often does not appear until after approximately 80 days of storage and is considered to be one of the most important reasons for storage pile deterioration. Rot typically begins in the center of the crown and extends downward developing a cone shaped decayed area. Decayed tissues often have pockets lined with white mycelium of the causal fungus.

Infected seed is considered to be the primary source of inoculum, although ascospores have also been shown to initiate infection of seed plants after overwintering in overwintering infected root debris (Bugbee and Cole, 1981). Damping-off is favored by cool (5—20°C) weather and conditions that slow seed germination. Plants that survive seedling infection may continue to harbor the fungus systemically (Edson, 1915). Under moist conditions, conidia exude out of pycnidia on hypocotyls and may also cause leaf spots and lesions on seed stalks when spread by splashing water. The percentage decay in storage is highly correlated with the percentage of infected seed planted.

This disease is best controlled by planting seed free of infection. Seed should be produced in dry areas under surface irrigation. Seed treatments including hot water, thiram, prochloraz and benzimidazole fungicides will reduce or eliminate seed infection. Field root rot is best reduced by growing the crop with minimal stress due to water and nutrient availability. Decayed roots associated with tare or old storage piles should not be placed in production fields. The fungus has been shown to be able to survive in rotted root tissues for up to 26 months.

CHARCOAL ROT

Charcoal rot caused by *Macrophomina phaseolina* (Tassi) Goid. (syn. *M. phaseoli* (Maubl.) Ashby) is common in the hot interior valleys of California and it has also been reported in Greece, Egypt, Iran, Hungary, India and several countries in the former USSR (Schneider and Whitney, 1986). Like other root rots, *Charcoal rot* reduces root yield, sugar percentage and purity and makes roots less storable. Losses range from 0—30%, with high losses only occurring where beets are produced under high temperatures (31°C optimum) and significant moisture stress. Initial signs of this disease are pronounced wilting of the foliage, which subsequently turns brown and dies. Root lesions are brownish-black and are irregular in shape, typically occurring in the crown region. Old lesions rupture to expose masses of charcoal-colored microsclerotia. Decayed areas of the internal root are initially mustard yellow and subsequently change in color to buffy citrine. In advanced stages of decay, root tissue is brownish-black, with masses of microsclerotia commonly found in cavities. Such roots may ultimately shrink and become mummified.

The fungus survives as microsclerotia in soil or host tissue for at least two years. Microsclerotia are formed in beet and other hosts such as common bean, cotton, maize, potato, sorghum, soybean, strawberry, sunflower and sweet potato (Collins et al., 1991, Su et al., 2001). Because of the longevity of microsclerotia and the broad host range crop rotation is not a practical control. Control measures should focus on preventing moisture stress by using proper irrigation methods or using cultural practices that conserve soil moisture.

FUSARIUM ROOT ROT

Fusarium root rot, caused by *F. oxysporum* f.sp. *radis-betae*, has been observed in Texas, Colorado and Montana and likely occurs in other sugar beet producing areas of the U.S. (Franc et al., 2001). It has likely been overlooked because it often occurs as part of a complex with other root diseases such as *Rhizoctonia root* and *crown rot*, *Aphanomyces root rot* and *rhizomania* and with the wilt disease *Fusarium yellows*. Other *Fusarium* species such as *F. culmorum* and *F. solani* have been described as causal agents of root rot diseases in sugar beets in the U.K.

Foliar symptoms associated with *Fusarium root rot* are similar to those of *Fusarium yellows* caused by *Fusarium oxysporum Schlecht* f.sp. *betae Snyd & Hans*. These include intervenal yellowing, general chlorosis, wilting and brown scorched leaves. Initially wilted plants may regain turgor at night, but plants severely affected by *Fusarium root rot* seldom recover completely. Root symptoms are characterized by a distinctive black external rot on the distal tip of the primary taproot and necrosis of vascular elements.

Fusarium oxysporum f.sp. *radis-betae* is morphologically similar to the *F. oxysporum* f. sp. *betae.* Microconidia (3—5 x 8—10 μm) are produced in false heads and globose to ovoid chlamydospores (4—7.5 x 20—30 μm) are common. Macrocondia are produced only sparsely on common media. These species can be differentiated by analyses utilizing RAPD PCR, isozymes from at least 3 enzymes and vegetative compatibility groupings (VCGs) (Harveson and Rush, 1997).

The pathogen most likely survives in the soil between host crops as chlamydospores and observations suggest that it can survive for long periods without a host. Disease development is favored by temperatures in excess of 27°C (Harveson and Rush, 1998). Some isolates are specific only to sugar beet while others can cause disease in other plants in the family *Chenopodiaceae*, such as spinach (*Spinacia oleraceae*) and red root pigweed (*Amaranthus retroflexus*).

This disease is best controlled by the use of resistant germplasm and practices that minimize moisture stress. Early planting that allows plant development before conditions favor infection, crop rotation with non-host crops and control of weeds within the family *Chenopodiaceae* are also thought to be effective management practices.

PYTHIUM ROOT ROT

Pythium root rot caused by *Pythium aphanidermatum* (Edson) Fitzp has been reported in the states of Arizona, California, Colorado and Texas in the U.S. and in Canada, Austria and Iran. *P. deliense* Meurs, has been reported to cause a root rot with different symptoms in Arizona and Texas (R u s h, 1987). Root rot caused by *P. aphanidermatum* is characterized by wilting and a watery dark-brown to black rot of petioles and the interior portion of the taproot. On the exterior of the root lesions are dark colored and irregular in shape and maybe similar to those caused by *Rhizoctonia crown and root rot*. Infected roots often have a "rubbery feel". Root rot caused by *P. deliense* is characterized by a marbled brown to black root rot that progresses upward in the taproot from infections of secondary roots.

These *Pythium* species survive in the soil as oospores (17—19 μm). When conditions are favorable, the oospores germinate directly or produce zoospores. Favorable conditions for infection and disease development are soil temperatures of 27°C or greater for at least 12 hours and wet soil conditions (0 to –0.1 bar). Epiphytotics have been associated with the fore-mentioned environmental conditions and alkaline soils with high levels of soluble salts and exchangeable sodium (H i n e and R u p p l e, 1969; v o n B r e t z e l et al., 1988).

Management of this disease is best accomplished by avoiding practices that promote prolonged periods of high soil moisture. The use of hymexazole and metalaxyl seed treatments or metalaxyl soil treatments may be helpful.

PHYTOPHTHORA ROOT ROT

Phytophthora root rot caused by *Phytophthora drechsleri* Tucker has been observed in the states of California, Colorado, Idaho, Montana, Oregon and Utah in the U.S and in Iran. In England, *P. megasperma* has been reported to cause as similar root rot. In nearly every report beets are exposed to excessive soil moisture when temperatures are high (28—32°C). This member of the *Oomycota* survives in the soil as chlamydospores (7—15 μm) and oospores (24—36 μm). Oospores germinate to form sporangia which release zoospores that infect plants. Symptoms include wilting and a wet rot at the base of the taproot that eventually extends upward toward the crown. There is a sharp margin between rotted and healthy tissues. Wilted plants may recover at night in the early stages of this disease. This disease often occurs when wilted beets are irrigated during hot weather. Disease progress will slow markedly when soil temperatures cool.

Management of this disease is best accomplished by avoiding practices that promote prolonged periods of high soil moisture (S c h n e i d e r and W h i t n e y, 1986).

RHIZOPUS ROOT ROT

Rhizopus root rot caused by *Rhizopus stolonifer* and *R. arrhizus* has been reported as occurring in Arizona, California, Wyoming and Colorado in the U. S. and in Canada (Alberta and Ontario) and Italy, Iran, France and many countries that made up the former USSR. Like other root rot diseases, the first symptom is wilting of the foliage. In this case the foliage rapidly wilt and becomes dry and brittle, collapsing on the crown similar in appearance to plants affected by *Rhizoctonia crown and root rot*. Initially, gray to brown lesions are seen on the taproot. These lesions gradually spread downward from the crown and eventually are covered with a white mycelial growth that later takes on a dark appearance as sporangia develop. Internal decay is brown and spongy in appearance. In advanced stages there are cavities in the decayed area filled with a fluid with the smell of vinegar. Secondary roots are generally unaffected.

Both *Rhizopus* species are considered to be common saprophytes on organic matter and only weak parasites on sugar beet. Sporangia are airborne and infect sugar beet only when the beet is stressed by excessive soil moisture, mechanical damage to the crown or insect damage. High temperatures (30—40°C) are required for infection and disease development by *R. arrhizus* while low temperatures (14—16°C) favor *R. stolonifer*.

This disease is best controlled by avoiding excessive moisture and reducing mechanical damage or insect damage to the crown. Implementation of techniques that favor healthy, rapid plant growth will be helpful in reducing damage (S c h n e i d e r and W h i t n e y, 1986).

SOUTHERN SCLEROTIUM ROOT ROT

Southern Sclerotium Root Rot caused by the fungus, *Sclerotium rolfsii*, which has been reported as occurring in the southern and southwestern U. S. and in Argentina, Bangladesh, Brazil, Czechoslovakia, Egypt, Italy, India, Israel, Japan, Korea, Morocco, Pakistan, Spain, Taiwan and Uruguay. This fungus is found worldwide and will like cause root rot of sugar beet wherever frozen soil does not occur in the winter. The fungus survives in unfrozen soils as sclerotia and anything that moves infested soil will spread the pathogen. The fungus has a host range of more than 200 species. Disease development is favored by moist soils and temperatures in the 25—30°C range (S c h n e i d e r and W h i t n e y, 1986).

Symptoms initially include unthrift top growth and wilting. Infected roots are covered by white cottony mycelium and masses of white tan-orange to brown sclerotia. Internal decay is a watery soft rot.

This is a difficult disease to manage because of the wide host range and pervasive presence of sclerotia in tropical to subtropical areas. Rotations that include less susceptible hosts such as wheat, barley, corn, alfalfa or asparagus will reduce inoculum potential. Application of adequate nitrogen and other nutrients will provide vigorous growth that will reduce losses (Leach and Davey, 1942). While resistance is known in breeding lines no resistant cultivars are known to exist. Use of soil applications of carboxin, chloroneb, PCNB and some triazole class fungicides have provided control in sugar beets and other crops such as peanut, although there are no registered uses for these fungicides on sugar beet in the U.S.

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ТРУЛЕЖ КОРЕНА ШЕЋЕРНЕ РЕПЕ

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Резиме

Болести трулежа корена представљају највећи проблем у производњи шећерне репе свугде у свету где се она гаји. Све ове болести су проузроковане земљишним гљивама и карактеристично је да представљају највећи проблем у областима у којима се током дужег низа година производи репа и где се примењује узан плодоред. Најважније болести трулежи корена шећерне репе проузрокују патогени *Rhizoctonia solani* (AG-4, AG 2-2 IIIB i AG 2-2 IV), *R. crocorum*, *Aphanomyces cochlioides*, *Phoma betae, Macrophomina phaeseolina, Fusarium oxysporum* f.sp. *radicis-betae, Pythium aphanidermatum, Phytophthora drechsleri, Rhizopus stolonifer, R. arrhizus* и *Sclerotium rolfsii*. Међутим, сви ови патогени који се преносе земљиштем нису уочени у свим областима производње шећерне репе. Важност било којег од ових патогена, проузроковача трулежи корена у одређеној

производној области, у великој мери зависи од температуре, земљишних фактора као што су влага и соли у земљишту, производне праксе и плодореда. Многи од ових патогена проузрокују губитке и после вађења репе, у складиштима. Рад ће се усредсредити на распрострањеност ових патогена, идентификацију обољења и циклус развоја болести, епидемиологију и интегралне мере сузбијања. Интегралне мере сузбијања ових патогена укључују сорте отпорне на болести, незаражено семе, избегавање стреса, агротехничке мере као што су наводњавање и примена фунгицида. Биће размотрена примена азоксистробина за сузбијање ризоктониозне трулежи главе и корена репе у односу на методе примене и дозе, времена примене и у поређењу са другим фунгицидима.

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THE MOST IMPORTANT SUGAR BEET PESTS IN UKRAINE AND INTEGRAL MEASURES FOR THEIR CONTROL*

ABSTRACT: The report delivers the origins of the insect complex formation on sugar beet fields in Ukraine. Biological, ethological and ecological peculiarities of the most numerous pest species have been shown. Regularities of many-year dynamics of pests, the problems of phytosanitary state of agrocenosis of sugar beet fields and conceptual grounds of pest control in contemporary conditions have been substantiated.

KEY WORDS: sugar beet, insect complex in sugar beet fields, population dynamics, pests, pest control, biological method of pest control, cultural practices, soil, homeostasis, biocenosis, agrobiocenosis, succession, pest resistance to plant genotypes, trophics, fecundity, forecast, adaptivity, ethology, ecology, ecosystem

Since the great discovery in 1474 by Andreas Marggraf, history of improvement of sugar beet growing has had a relatively short period. Nevertheless, the grandiose efforts to change multi-tillering wild forms of *Beta vulgaris* L. into high-productive hybrids with a single tiller have been conducted.

However, now on 258th year of commercial growing of sugar beet, numerous species of pest organisms lay obstacles for high yield of this crop.

In Ukraine, where growing of the crops is of supreme importance, the dangers that the part of the pests pose are as serious as everywhere. In Ukraine, commercial growing of sugar beet continues for more than 180 years. Over this period, areas under sugar beet fields have grown steadfastly **(1)**. In these circumstances, the number of herbivores insects adapted to feeding on this crop has been ever-increasing. Now, the area growing sugar beet has been stabilized, reaching 900,000 ha over diverse soil-climatic zones. That is why the species composition of pest arthropods in sugar beet fields is widely heterogeneous **(2)**.

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In agrobiocenosis of a sugar beet fields, 146 species of insects (*Insecta*) inhabiting the soil surface and 407 species in the stem stand have been discovered. The beetles (*Coleoptera*) dominate (195 species). The flies (*Diptera*) are numerous (71 species). The number of other species strains is as follows: sucking insects — the bugs (*Hemiptera*), 68; the aphids (*Homoptera*), 27; the wasps (*Hymenoptera*), 29. The remaining strains are represented in the insignificant number.

On the soil surface, the participation of beetles (*Coleoptera*) is 77%. The following 22 families in decreasing order are: weevils (*Curculionidae*), leaf-beetles (*Chysomelidae*), carabids (Carabidae), lady-beetles (*Coccinelidae*), click-beetles (*Elateridae*) and others. In flies (*Diptera*), 24 families are known, including *Bibionidae, Opomysidae, Syrphidae, Tupulida*, and others. The bugs are presented by 10 families *Miridae, Pentatomidae, Nabidae, Anthocaridae*.

Homeostasis of primary and secondary cenoses is characterized by diverse levels of stability over time (in agrocenoses, the successions are limited by antropic factor), which exerts effect on species composition, constancy and distribution of insects in stations depending on ecological and especially trophic conditions.

In natural cenoses, species diversity is nearly twice as high as comparing to that in agrocenoses, although in the latter, the biomass of insects is much lesser than that in the former. Primary cenoses are the main factors of maintenance of stable equilibrium in ecosystems of any level. Mini natural reserves serve as the best source of the stability. Also, the plots of limited agricultural management are useful for this aim. In such conditions, potential, sporadic and extremely dangerous pests of sugar beet have been formed. The number of such tiresome pest species is usually close to 40 items **(3)**. Over the period of growing sugar beet in Ukraine, great many studies concerning biology of the pests and methods of their control have been conducted (Ю. П. Бічук, 1971, Ю. М. Брунер, 1947, Е. М. Васільєв, 1906, 1907, 1908, Г. Ф. Гапонова, 1959, О. Н. Житкевич, 1959, Е. В. Зверозомб-Зубовський, 1928, 1934, 1938, 1956, А. В. Знаменський, 1926, А. І. Зражевський, 1959, Е. М. Кітіцин, 1959, Й. Й. Кораб, 1927, 1930, М. О. Кузьмін, 1936, І. В. Ліндеман, 1928, 1929, 1930, К. А. Орлачова, 1956, В. Ф. Палій, 1959, О. Й. Петруха, 1940, 1961, 1967, 1980, З. М. Савицька, 1968, Г. Ю. Соболь, 1958, М. П. Чарковський, 1959).

However, there are great many problems, which need new, non-ordinary solutions. They should be based on the systematic approach to understanding regularities of interrelations in fauna of pests and useful insects in agrobiocenosis with the aim of developing ecologically directed methods of managing population dynamics, taking into account the protection of the environment from pollution (С. О. Трибель, 1989, В. Т. Саблук, 1989, В. А. Санін, 1971, В. П. Федоренко, 1998).

Now, phytosanitary situation in Ukraine gets worse which is the result of a number of factors, in particular slow reforming of agriculture. This resulted in the increase in density of pests and negative processes in agrobiocenoses that will lead to non-predictable successions.

Therefore, concerning the organization of phytosanitary monitoring, it is necessary to take into account a number of factors, including contemporary economical reality, global warming, abnormal weather changes, adaptation of insects to new trophic conditions, the appearance of resistant genotypes, intensive translocation of dominants in cell nucleus of pests and useful insects, the disturbance of crop rotation. These factors determine the increase in dangers caused by the part of pests.

Only by taking into account all these factors, it is possible to improve and develop contemporary system of protective measures against pest organisms.

MATERIAL AND METHODS

The material was collected in all the zones in Ukraine where sugar beet is grown. The tests were of diverse character: laboratory, greenhouse, separate field and farm (full-scale). They were conducted in the zone of the Central Forest-Steppe in Ukraine (V. P. Fedorenko, 1998).

Studies of insect complex were conducted in sugar beet agrobiocenoses within the beet rotation and in adjacent cenoses (fallows, forest edges, shelterbelts, ravines) according to the methods of the Institute of Sugar Beet of UAAS (О. П., Петруха, 1969, 1976$_a$, О. Й. Петруха, А. П. Бутовский, Г. Е. Соболь, 1981, В. П. Федоренко, 1985).

In doing so, the soil surface (on square meter plots) under plants covering the edges of shelterbelts and forests were observed in 15 points of the field.

In fields of inter-tilled crops, the evaluations were conducted on 100 plants distributed by 10 pierces in 10 points of the field. Population density was recorded by counting insect number or by means of evaluating in numeric scores. Also, 100 wages by a sweep net were used.

Density of flea beetles was counted on 25 x 25 cm plots with the Petlyuk's box.

Barber's soil traps improved by В. П. Федоренко (1997) were used for counting soil insects.

Density of *Atomaria linearis* Steph. beetle was counted by means of the special four-angle probe — collector 10 x 10 x 10 cm in dimensions. During season, the density of the pests was counted in diverse layers of the soil. In doing so, a cylindrical soil auger with 11.28 cm diameter was used.

The soil-dwelling pests were counted by soil excavations by digging 50 x 50 x 50 cm pits.

Density of beet root aphid was counted by taking soil samples with colonies of the aphid. The samples were washed by water. Distribution of the aphid along soil layers was studied at following depths: 0—5, 6—15, 16—25, 26—40, 41—60, 61—80, 81—100, 101—120, 121—130 cm.

Density of *Tanimecus* beetle was counted by soil excavations at the following depths: 0—15, 16—30, 31—45, 46—60, 61—80, 81—100, 101—120, 121—140, 141—160 cm and more. Within each of the above depths, a 2 cm soil layer was taken for counting the beetles. Dimensions of the pits were 100 x 100 cm.

The effect of toxity of host-plants on fecundity of *Tanimecus* beetle was studied by rearing of the insects in cages of glass jars. The bottom of the jars was filled with sand, which had been screened through a sieve with 0.5 mm cells in diameter. This diameter was less than that of eggs of the beetle. Therefore, when screening the sand, eggs were left in the sieve.

Fecundity of the beet root aphid was studied on samples of beet roots in Koch's dishes under soil cowlets. The dishes were kept in a polytermostat. Peculiarities of aphid's development were studied by dissection of aphid abdomen under a microscope.

Pest resistance to pesticides was studied on the example of the leaf beet aphid according to the method of И. В. Зильберминц, 1984.

Vegetative tests were conducted according to the conventional method (О. Д. Сказкин, Е. И. Ловчинская, Т. А. Красносельская, 1948).

Field tests were conducted in a special scientific crop rotation system according to the conventional methods (К. А. Гар, 1963, Б. А. Доспехов, 1985, Ф. Вагнер, 1965).

The level of affection of plants by pests dwelling above the soil surface was studied according to the scale with four numeric scores:

1 — less than 25% of leaf surface affected;
2 — 26—50% of leaf surface affected;
3 — 51—75% of leaf surface affected;
4 — 76—100% of leaf surface affected.

For every pest species, the average numeric score and the coefficient of colonization of plants was calculated according to the formula:

$$C_c = \frac{A \cdot B}{100}$$

Where $\mathbf{C_c}$ is the coefficient of colonization of plants; A is the percentage of beet plants colonized by pests; B is the average numeric score of damage or colonization (the sum of numeric scores divided by the number of damaged plants).

Evaluation of effectiveness of insecticides was conducted by means of placing the insects in the test cages.

The indices, which characterize the structure of insect populations inhabiting beet crop rotation system were calculated according to the following formulae:

1. Coefficient of species diversity (Fisher R. A., Corbet A. S., Williams C. B., 1943):

$$d = \frac{S-1}{\lg N}$$

Where **d** is the coefficient of species diversity; **S** is the total number of species in biocenosis; **N** is the total number of insects at counting.

2. Coefficient of density of a species (В. Ф. Палій, 1961):

$$C_a = \frac{p \cdot d}{100}$$

Where $\mathbf{C_a}$ is the coefficient of density of separate species in entomofauna; **p** is the percentage of ratio of a given species to the total number of collected insects; **d** is the occurrence of a given species in the inspections.

3. Coefficient of resemblance of entomofauna of diverse cenoses (Mounford M. D., 1962):

$$J = \frac{2j}{2ab - (a+b)j}$$

Where **J** is the coefficient of resemblance; **a** and **b** are the numbers of species in points of counting (stations); **j** is the number of species similar for all the stations.

For characteristic weather conditions which influence the development of insects, besides values of air temperature and precipitations, the hydrothermal coefficient (HTC) was calculated according to the formula by Селянінова (1928):

$$HTC = \frac{\text{sum of precipitations} \times 10}{\text{sum of effective temperatures above } 10^\circ \text{C}}$$

DISCUSSION OF RESULTS

In last years, the areas of application of pesticides have decreased 3.4 times (**4**). This led to sharp worsening of phytosanitary state in agrocenoses, in particular to the increase in colonization by soil pest insects 2.8 times (**5**).

The significant worsening of the phytosanitary state was promoted by sharp cutting down of the number of laboratories of biological methods for pest control in Ukraine. Their number was 268 in the mid 1990s, whereas now, only 73 of them remained.

So, in 1991, biological method of plant protection was applied on the area of 5 million ha, whereas at present, on only a million ha. The causes of growth of pest density and the increase in areas of their damage are the structural changes in agricultural landscapes induced by abandoning vast areas of arable lands.

The global warming has also contributed to conventional zonal distribution of some pests.

So, for example, from the beginning of 1994, the increase in density of tiresome polyphagous pest, the locust *Calliptamus italicus* L. was observed. This species, being a typical pest in the south of Ukraine, now is getting common in the forest-steppe zone and even in the forest zone (**6**). This pest occupies 250.000 ha with the density up to 5.000 insects per square meter.

The effect of the global warming might be traced not only in polyphagous pests, but also in the specialized sugar beet pest, the weevil *Bothynoderus punctiventris* Germ.

In fact, after the prolonged depression, from the beginning of 1992, the growth of population density of this species takes place. In 2000, in infestation spots, its density reached 68 beetles per square meter.

The growth of population density is promoted by greater sum of effective temperatures that has been observed in recent years. Indeed, if the sum over two years is greater than 1.135°C over two seasons, the probability of increase in its density is high (О. Й. Петруха, 1981).

This regularity has been substantiated in last years, because the density of weevil approaches its density in 1932—1940. In that time, 14.387 tons of beetles were collected per day (А. С. Мищенко, И. С. Любомудров, 1941) **(7)**.

Anomalous sharp changes of weather conditions also influence the damage exerted by sugar beet pests and on efficiency of protective measures. In spite of the global warming, mighty onsets of cold take place in spring. Thus, in 1998 and 1999, late frost in the first half of May, when air temperature decreased to 8°C below zero, postponed the appearance of *B. punctiventris* on the soil surface. However, the late frost retarded germination. Therefore, the plantlets evaded the damage.

In 2002, at late frosts, mass appearance of weevil took place by in "waves". The first, most potent one was recorded from 13th to 16th April. In that period, the density of weevil was 1.0 beetles per square meter. The second "wave" was recorded at the beginning of June. This situation decreased the density of weevil as well as the damage.

Weather situation influences vertical migrations of wire-worms in the soil and the efficiency of toxication of plantlets **(8)**. At late onset of spring, fresh weather decreases the activity of wire-worms and allows sugar beet to grow. As the result, the damage gets lessened. On the contrary, in the early spring, the damage is great. Therefore, sugar beet needs to be protected by means of seed treatment with carbofuranous insecticides.

At delayed migration of wire-worms, seed treatment insecticides with prolonged period of toxity have to be used (Tiametoxam or Imidocloprid).

There are diverse views concerning the effect of weather on the activity of root beet aphid (*Pemphigus fuscicornis* Koch.). It is supposed that drought promotes the activity of the aphid. But (В. О. Мамонтова, 1975) it has been reported that the aphid develops better in the conditions of moderate moisture.

The studies by the author that have been conducted over a twenty-year period showed that the best conditions for the development of the aphid are at high values of HTC. The increased harmfulness of the aphid at drought is explained by the theory by Academician М. С. Гілярова (1948). He has shown that feeding by tissues rich with juices is one of the main adaptations of soil-dwelling insects for protection against desiccation. The aphids consume significantly more plant juices than it is needed for providing nutrients compensating intensive evaporation through thin chitinous outer coverings **(9)**.

Adaptation to new trophic conditions is traced well on the example of beet leaf aphid (*Aphis fabae* Scop.). Studies over 19 years of effect of mineral fertilization on density of the aphid showed that the increased rates suppressed aphid development from 1973 up to 1983; in some years 3—5 times (10). However, from the beginning of 1984, the difference between test and check variants was not recorded. This is an effect of global application of the increased rates of fertilizers. Firstly, this factor suppressed the aphid. Since than, this factor ceased to be the limiting one. The adaptation of the aphid was promoted by its continuous changes of generations, great fecundity and wide natural variation.

Contrary to leaf beet aphid, root beet aphid reproduces only parthenogenetically, i.e. independently of panmixia. Therefore, their density is determined mainly by trophics. It was discovered that at the beginning of vegetation, larvae of root beet aphid prefer colonizing weeds of *Chenopodiceae* family. Here, they also develop better. In the second part of vegetation, they colonize sugar beet intensively. The increased fecundity of root beet aphid (*Pemphigus fusicornis* K o c h.) was proved experimentally. When setting the aphid on the sugar beet, brood of a female reached 1319 insects for 25 days, whereas at setting on the weeds, the brood was only 310 insects. In the past, when sugar beet was not cultivated, in the second part of the season, the aphid seemed to be suppressed on the weeds. Later, when sugar beet began to be grown, the aphid got the host-plant, which provided these insects with favorite food over season.

This fact promises the means of suppression of the aphid by exclusion of weeds of *Chenopodiceae* family. In doing so, the trophic chain would be broken.

On areas of non-arable lands, where the weeds are abundant, density of the aphid is the most stable. Dense stem stock of cereals suppresses the weeds that postponed the development of the aphid. But after harvesting, the weeds thrive and the density of the aphid grows. Then, they colonize sugar beet. Therefore, after harvesting of cereals, the weeds need to be destroyed by clean tillage **(11)**.

The specific trophic relations are traced in the cassid beetles.

Beetles (*Cassida nobilis* L.) colonize fields in spring, where they before the appearance of sugar beet plantlets feed on weeds of *Chenopodiceae*, *Caryophyllaceae* and *Amaranthaceae* families.

In last years, in spring, when plantlets of sugar beet are protected by insecticides, *C. nobilis* leaves these fields and feeds on wild plants and beetles return on sugar beet after its toxity gets lost.

In the beginning, *C. nebulosa* L. concentrates on *Chenopodiceae* weeds and only in the second part of the season it colonizes beet fields. Its trophic peculiarities significantly influence fecundity, time of development and therefore seasonal dynamics of density. These factors determine the tactics of control measures.

Indeed, *C. nobilis* has transformed into a typical inhabitant of sugar beet fields, whereas *C. nebulosa* finishes its life cycle on sugar beet only in some years with fecundity of only 4 egg clusters per female. This is a very low value comparing with fecundity on weeds, 19 or 33 egg clusters **(12 and 13)**.

Beetles of *C. nobilis* live till August, whereas beetles of *C. nebulosa* live till the end of September, when wild host-plants die. Therefore, the main role of sugar beet with the prolonged period of vegetation, which allows bridging a gap in the trophic chain is clear.

Due to its unique trophic possibilities, gray beet weevil (*Tanymecus palliatus* F.) also evades contact with toxicated plants in the stage of plantlets and therefore increases in density.

It was discovered that larvae of gray beet weevil are able to develop on roots of sugar beet, but they complete their development on roots of perennial weeds and leguminous grasses, because roots of sugar beet are harvested which brakes the trophic link of the larvae.

These polyphagous beetles feed on numerous crops and weeds. Therefore, regularities of seasonal and many-year dynamics of the species are determined mainly by trophic factors.

The greatest fecundity of this pest is observed at feeding on weeds *Cirsium arvense* S c o p. and *Convolvulus arvensis* L., whereas the least fecundity is observed in feeding on plants of *Chenopodiceae* family (**14**).

Littering of fields with *C. arvense* S c o p., *C. arvensies* and other weeds promoted wide spread of weevil in fields of crop rotation where its densitry is greater than that on sugar beet fields (**15).**

Such fields are continual sources of weevil reproduction. They enlarge its stock on sugar beet plantations.

Last years, as the result of wide application of seed toxication with carbofuran preparations, the ecolological situation changed. Results of studies have shown that mixed feeding on wild host-plants and on toxicated as well as non-toxicated plantlets of sugar beet promotes the appearance of gray beet weevil reproductive and adaptive heterosis that results in the increase in its fecundity (the bumerang-effect).

Due to this phenomenon, seed treatment during prolonged time did not provide the decrease in overall population density of weevils. On the contrary, this measure promoted the selection of resistant genotypes of this species. This means that with many insects, not only adaptation to new trophic conditions appears, but also genotypes resistant to certain group of insecticides are formed intensively.

The quickest development of resistant populations is observed in aphids, which is explained by the presence of numerous clones in their populations which differ from each other and with the fact that aphids are able to adapt to changed conditions in the process of natural selection. Aphids obtain resistance to insecticides during one or two seasons (M. C. Г і л я р о в а, 1948). The most prospective insecticides are those which do not pollute the environment. Therefore, the author studied the sensitivity of leaf beet aphid to Furadan, which has been applied in Ukraine for over 20 years.

As the material for the studies, two populations, Bilotserkivska (this is a zone of intensive, many-year application of this insecticide) and Kyivska (in this Region the preparation was never applyed) were used.

Toxical characteristic (LC_{95}) was determined for aphid populations taken in nature from diverse host-plants (goose foot and sugar beet) and for the laboratory population which was reared on sugar beet; seeds of beet were treated by Furadan **(16)**.

The comparison of sensitivity to this insecticide between two populations showed that the Kyivska population was 17 times more sensitive to Carbofuran than Bilotserkivska.

Thus, the toxication of sugar beet by means of seed treatment and decrease of toxicity of the plants in the period of colonization by the aphid promote selection of resistant forms of this pest.

Antropic influence. Worsening of ecological situation has led to the impoverishment of species composition of insects. In fact, the coefficient of species diversity, which was reconstructed by the author for 1946—1953, showed that the impoverishment reached 33%.

In interspecies competition due to the antropic factor, the transcyclic gradation of species with greater ecological valency took place. They enlarge ecological niches of certain trophical levels and take up dominate state in the nucleus of pests. In other words, intensive redistribution of dominants in the nucleus of pest species as well as of useful ones takes place.

Thus, according to О. П. Петрухи, А. П. Бутовського (1947), in the Kyiv Government from 1901, gray beet weevil dominated among other species of its genus and constituted about 70% of collected beetles. In 1927, participation of this species did not exceed 6% of the total number of beet weevils in April and 15% in May. At the same time, *D. punctiventris* had high density exerting heavy damage. Eventually, this species fell in deep depression. At the same time, the domination of *T. palliates* and of east beet weevil (*Bothynoderes foveicollis* Gebler.) enlargened. (**17**)

The monopoly of harmfulness of these species on the given trophical level was especially expressed on the background of decrease of *B. punctiventris*. Nevertheless, the increase in the population density of the latter weevil, which took place from the begining of 1992 was quite predictable because its outbreaks appear over 2—4 years with intervals of 10—11 years (С. О. Трибель, 1998).

Concerning wire-worms (*Elateridae*) dwelling in beet crop rotation systems, the ratio of species underwent changes as well. Thus, in 1952—1953, in stationary tests of the Department of Cultural Practices of Bila Tserkva Exp. Brd. Sta., the larvae of click beetle (*Agriotes gurgistanus* Fald.) dominated and constituted more than 90% of all click beetles found. Recent inspections (1994—2004) on the same fields showed that *A. gurgistanus* continued to dominate, but its participation lowered. (**18**)

The trend of significant increase of density of click beetles *Agriotes obscurus* L. and *Melanomus brucnnipes* Germ. was revealed, which earlier occurred in insignificant density only. Also, the density of click beetle *Selatosomus latus F.* decreased, whereas the density of click beetles *Agriotes sputator* and *A. ustulatus* Schll. stayed on the same level.

The change of dominating species was caused by the application of new technological processes in cultural practices and wide intensification of agriculture which modified ecological conditions. The latter promoted the species with wide ecological adaptability-polyphagous insects.

FORECAST

An intelligence service of crop protection is necessary for prevision of phytosanitary situation, for rational, skilful, timely and effective application of systems of protective measures. When such prerequisites are ignored, so called "sudden burstings of multiplication" are inevitable. Nevertheless, the forecast continues to be a weak link in the integrated plant protection.

Here is a notable fact. During the occupation of Ukraine by German Natsy in World War II, their administration maintained the local web of Forcast Service and every year published a map of density and distribution of the main pests of sugar beet.

Unfortunately, in last decades, this important service was weakened. Now, in this service, 190 Stations of Signalization and Forecast operate, with 247 members of the staff. This is insufficient for the valid forecast. In fact, the staff of State Service of Meteorology is as much as 20 times lower. Therefore, the reinforcement and modernization are needed for this link of protective measures based on the theory by О. Л. Чижевського (1995). He has teached us that the effects on live nature of the environment situated outside the soil should be taken into account.

The need for the above-mentioned modernization is demonstrated by the following fact: the converted method of forecast of leaf beet aphid (*Aphis fabae* Scop.), which is based on the counts of overwintering eggs and their mortality in this period is actually wrong because the correlation between the above values takes place in rare instances.

For the forecast of this species, it is advisable to take into account the values of the Hydro-thermal coefficient (HTC), rather than to count overwintering eggs (**19**).

The control measures express their efficiency on the background of proper cultural practices. I am sure that any other country cannot perceive the advantages of crop rotation, soil tillage, the application of nutrients as Ukraine can. Unfortunately, this country suffers catastrophic impacts: Chernobyl disaster, decline of agriculture after 1991 that has led to the appearance of vast areas of abandoned fields and to abundant littering of arable lands with weeds due to the lack of herbicide application. As the result, pest organisms, being earlier suppressed by severe control, now stay on high population density. These processes have reached the scale of the all-national disaster.

The negative effects of the decline on phytosanitary state of agrocenoses is expressed especially in crop rotation systems developed by scientific organizations. In fact, the inter-tilled crop rotation system promotes the decrease in density of wire-worms, because it makes unfavorable conditions for their existence. In the grain inter-tilled crop rotation, the presence of a field with perennial grasses promotes the increase in the density of soil-dwelling pests. (**20**)

Concerning the fertilizers, the optimal rate for sugar beet which would essentially decrease population density of soil-dwelling pests is the treatment with 40 metric tons per ha manure and N_{80}-P_{100}-K_{100}. (**21**)

Optimizing the technological agricultural processes on the background of developed cultural practices oppresses the reproduction of soil-dwelling pests up to the density close to ETHs. This gives a possibility of decreasing insecticidal loading on agrobiocenoses, because in the integtrated systems of plant protection, the application of modern chemical preparations on the basis of using new technologies was foreseen.

In particular, this is "seed dressing" with insecticides, which is now most economically and ecologically purpousfull technological method. So, all the seeds of sugar beet are treated with the protecting and stimulating preparations in seeds factories. Instead of carbofuran preparations that had been applied in Ukraine since 1985, insecticides of new generation on the basis of active ingredients — imidacchloprid and tiamethoxam came into usage at present. These insecticides have significant advantages in comparison with carbofuranous ones concerning their efficiency, persistence and safety for the environment.

In fact, at the application of Gaucho, in the first 24-hour period, 85% of weevil beetles were affected, whereas 60% of them died. In five 24-hour periods, the mortality of weevil reached about 90%. (**22**) Concerning Cruiser efficiency on sugar beet (**23**), the coefficient of damage of host-plants by weevil *B. punctiventris* was 3.5 times less comparing with the control and the damage caused by leaf beetles, twice less. Efficiency of Tiametoxam is twice as much higher as that of carbofuranous seed dressing preparations. (**24**)

With the aim of increasing efficiency of insecticides for the sake of synergism and taking into account species composition of herbivores, it is purposeful to treat the seeds with preparations of diverse activity. So, in the tests being carried out in 2004, it was stated that joint treatment of seeds by Force and Cruiser was more effective than separate treatment by the preparations (**25**).

Such protection of sugar beet is ecologically oriented and by author's observations has no negative effect on useful insects (**26**). Density of the latter, in Barbar's traps was practically the same, both for the control and for the variant with systemic insecticides for seed dressing being applied.

Beside seed dressing with above-mentioned insecticides, the efficiency of application of preprations with active ingradients Carboxan-Marshal (25% i.e.) and Flagman (10% i.e.) was also studied. In doing so, they were carried in rows with the help of the pump of peristaltic action (**27**).

This test bears evidence that pre-sowing seed dressing in combination with droplet application of liquid preparations in the soil at sowing allows the 5-time decrease in the density of wire worms.

Taking into account all these pecularities of phytosanitary state in agrocenoses of sugar beet fields, it is possible to develop the scientifically substantiated system of integrated protection for sugar beet from pests (**28**).

Table 1. System of integrated protection of the sugar beet from the pest insects

Calendar terms and a stage of plants development	Pest insects	Organizational and economic measures
1	2	3
1. In a link crop rotation	Complex of the pest insects	1. Crop rotation 2. System of soil treatment 3. System of fertilizing 4. Monitoring of phytosanitary state fields (field history)
July-October A field of preceding crop	The soil-dwelling pest insects: polyphagous and specialized ones (*Elateridae*, grubs, the beet cyst nematode, the sugar beet root aphid)	1. Forecast the yield of sugar beets. 2. In the link with perennial grasses, green corn-soil treatment by type of a half-fallow (shelling in two strips, fertilizing, august plowing with the following cultivation of autumn plough-land), that provides breaking off of trophic connection of herbivores, their control by mechanical means, activation of entomophages. 3. In the link with black fallow-system of soil treatment by type of improved autumn plough-land (two shelling in perpendicular directions with interval 12—14 days), fertilizing, autumn plowing of field.
October A field under sowing Places of the pest insects over-wintering	The soil-dwelling pest insects: *Curculionidae*, flea beetles, *Cassida nebulosa* L., *Cassida* nobilis L.	Autumn inspection of areas of the pest insects wintering, determination of danger degree for sugar beet fields.
October-November Field after harvesting of beets	The beet mining flies, *Pegomyia hyosciami* Panz., *Atomaria linearis* Steph., *Bothynoderes punctiventris* Germ., pupae of the leaf-eating *Noctuidae*	Clearing of fields from plant remains, plowing of a field in a depth more than 25 cm. Plow-downing of pest insects into more deeper layers of soil, lifting of ones from deep layers on the soil surface, predation of them by birds, mechanical damages, destruction of places of wintering (pupae and larvae into cocoons), increasing in activity of diverse predators.
December-January	Complex of the pest insects	1. Evaluation of phytosanitary situation (state) of sugar beet fields, planning of a differential system of every field. 2. Order for treatment of seeds with insecticides that provide effective control of herbivores. 3. Planning of the differential rates of sowing per ha, treatment of seeds with insecticides.

March-April	Complex of the pest insects	Expended forecast of danger degree — evaluation of situation.
April Preparation of the soil, sowing of beets	Complex of the pest insects	Meticulous flattening of soil surface and driving of the soil surface 0—5 cm to a small-crumb structure. At density of soil-dwelling pest insects per m^2: To 1.5 times than ETH — increasing of rate of sowing per ha in 1.5 times 1.6—3 times then ETH — increasing of rate of sowing per ha in 2 times above 3 times than ETH — increasing of rate of sowing per ha > 2 times
April — 2nd 10 days-period of May Plantlets — two pairs of leaves	Flea beetles, *Curculionidae, Cassida nobilis* L., *Cassida nebulosa* L., *Opatrum sabulosum* L., *Silphidae* (*Aclypaea*).	At treatment of seeds with systemic insecticides (a. i. imidachloprid, theametoxam) — monitoring of the pests population density and degree of plant damage. At population density > 3 ETH or leaflet damage > 25% of plants — spraying of the border strips, infestation spots or all the field with composite preparations (chlorpyriphos + cypermetrin) or microcapsulated ones (Parachute — a. i. methyl-parathion; lamda-tsydalotrin — Karate Zeon 050 CS), or tanck mixtures POC + perithroids in their half-rates.
The 2nd half of May-June Three pairs of leaves — closing of leave canopy in rows.	*Aphis fabae* S c o p., *Gnorimoschema ocellatela* B o y d., *Pegomyia hyosciami* P a n z., *Noctuidae, Loxostege sticticalis* L., *Bothynoderes punctiventrus* G e r m., clusters of *Noctuidae*	Monitoring the state of fields (pheromone traps for the leaf-mining moths and *Noctuidae*; or troughs with melasses that is fermenting). Mellowing of inter-rows with strewing of rows, treatment of fields with systemic insecticides (a. i. dimethoat, imidachloprid, acetamiprid) against the sucking and mining pests and against *Noctuidae* and beet web moth in a period of oviposition (taking into account damage degree) — mass release of the *Trichogramma* spp. in three terms and application of biological preparations on the basis of *Bacillus thuringiensis* or treatment by inhibitors of chitin synthesis (a. i. diflubenzuron, lufenuron, teflubenzuron), that provides protective effect for 30—40 days. At appearance of larvae L_1—L_3 — application of the composite preparations as Nurel-D (a. i. chlorpyriphos + cypermetrin) or microcapsulated ones (Parachut — a. i. methyl-parathion; Karate Zeon 050 CS — lambda-cygalotrin) that provide protective effect for 20—25 days. Treatment by the boom sprayers in the evening.

July—September	*Aphis fabae* Scop., *Pegomyia hyosciami* Panz., *Gnorimoschema ocellatela* Boyd., *Loxostege sticticalis* L., *Pemphigus fuscicornis* Koch., *Hemiptera, Cicadinae, Nematodes.*	Monitoring the state of fields (pheromone traps for the mining moth, *Noctuidae*) or troughs with melasses that is fermenting. Mellowing of inter-rows with strewing of rows, treatment of fields with systemic insecticides (a. i. dimethoat, imidachloprid, acetamiprid) against the sucking and mining pest insectc and against *Noctuidae* and beet web moth in the period of oviposition (taking into account damage degree) — mass release of the *Trichogramma* spp. in three terms and the application of biological preparations on the basis of *Bacillus thuringiensis* or treatment by inhibitors of chitin synthesis (a. i. diflubenzuron, lufenuron, teflubenzuron), that provide protective effect for 30—40 days. At appearance of larvae L_1—L_3 — the application of the combined preparations as Nurel-D (a. i. chlorpyriphos + cypermetrin) or microcapsulated ones (Parachutemethyl-parathion; Karate Zeon 050 CS — lambda-cygalotrin) that provide protective effect for 20—25 days. Treatment by the boom sprayers in the evening. At appearance of the infestation spots of beet cyst nematode, sugar beet root aphid — harvesting of the roots with immediate processing of row material.

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НАЈВАЖНИЈЕ ШТЕТОЧИНЕ ШЕЋЕРНЕ РЕПЕ У УКРАЈИНИ И ИНТЕГРАЛНЕ МЕРЕ ЗА ЊИХОВО СУЗБИЈАЊЕ

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Резиме

Индустријска производња шећерне репе у Украјини постоји око 180 година. Током овог времена многи инсекти су се адаптирали на усев шећерне репе.

Сада шећерну репу оштећују следеће штеточине: ларве *Elateridae* и *Scarabaeidae*, репина мрвица, бувач, *Curculionidae-Bothynoderes punctiventris* Germ., *Tanymecus palliatus* F. и *Psalidium maxillosum* F., *Cassidinae*, лисни минери, афиде листа и корена, *Noctuidae*, и други лептири.

Последњих година у Украјини је уочено погоршање фитосанитарне ситуације агробиценозе, што је условљено ефектом еколошких и економских фактора.

Ово је довело до великог повећања у нивоима како броја штеточина и ширења зона њихове штетности полифага, тако и специјализованих штеточина шећерне репе. Мигрирајући скакавац доноси шећерној репи специфичан проблем зато што, будући типична штеточина за јужне области, постаје корак по корак уобичајена штеточина и за шумско-степске и шумске појасеве.

Илустрација овог је *B. punctiventris* Germ., чији се број повећава након дужег периода кризе, почевши од 1922.

Високе ефективне температуре уочене последњих година погодовале су порасту популације *B. punctiventris*.

Интензивно ширење корова, омиљених биљних домаћина *T. palliatus*, почело је да погодује повећању популације ове штеточине.

Иста ситуација је и код ларве *Elateridae*. Густина њихове популације је катастрофално повећана, што доводи до редистрибуције доминантих међу најштетнијим врстама.

Последњих година поља шећерне репе оштећују инсекти који сисају: апхида *Aphis fabae* Scop. је постала економски значајна штеточина, али *Pemphigus fuscicornis* Koch., иако потиснут, представља потенцијално опасну штеточину.

Улога *Noctuidae* је знатно порасла поводом више или мање стабилне штетности репине мрвице, бувача и других штеточина.

Стога је у садашњим условима уведен фитосанитарни мониторинг агроценоза. Он пружа могућност за оптималније извођење и подизање вероватноће прогнозе развоја најопаснијих штеточина.

Израђена је и технологија примене *Trichogramma* sp. у области њене стабилне ефикасности.

Ширење подручја под репом (*Brassica napus* var. *oleifera*) и њихово увођење у плодоред шећерне репе су узрок повећању штетности репине чистолике нематоде која се проширила кроз област производње шећерне репе. Зато је у праксу уведен мониторинг нематода, уз помоћ система комплексних метода за сузбијање.

Један од најважнијих услова за интегралну заштиту шећерне репе је метод хемијског сузбијања густине популација штеточина методом облагања семена инсектицидима, уношењем препарата у земљу преко система кап-по-кап и прскањем поља током вегетационог периода, за шта се препоручују најбољи препарати и њихове мешавине.

Неопходно је истаћи да је висока ефикасност хемијске заштите шећерне репе могућа само на високом нивоу агротехнике.

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IMPORTANCE OF PRACTICAL MEASURES AND AGROECOLOGICAL CONDITIONS FOR FORMATION OF YIELD AND QUALITY OF SUGAR BEET IN VOJVODINA*

ABSTRACT: Yields of cultivated plants are the result of congruence between cultivated plant demands and agro ecological conditions of the region.

Fertilization is a practical measure associated with the highest losses.

In actual production conditions, deficiency in NPK nutrition results in losses up to 2.1—14.9 t ha^{-1}, excess amounts of these nutrients in losses of 5.8—18.9 t ha^{-1}. Quality losses are important, too.

Decreases in sugar content fluctuate between 0,2% and 0,9%, sugar utilization from 0,3—7,6% and total sugar losses from 380 to 1060 kgha^{-1}.

KEY WORDS: Fertilization, sugar beet, quality, yield

INTRODUCTION

Agricultural production is the manifestation of mankind's utilization of free nature. It is conscious and purposeful production that guarantees the survival of human species on our planet. People become less dependent on nature's unpredictability due to functioning of this production system. However, we must not forget the fact that we are the part of the same nature and that we should respect its laws.

In production technology of sugar beet or any other cultivated plant, all cultural practices are of the same importance, but yield will be defined by the most poorly applied one. A mistake in one cultural practice cannot be rectified by using other agronomic practices.

Sugar beet yields, obtained during 1960—1984 in France, Hungary, Italy, Romania and Serbia and Montenegro are shown in Graph. 1. Sugar beet yields in France had an increasing trend, with a growing rate of 998 kgha^{-1}. In our

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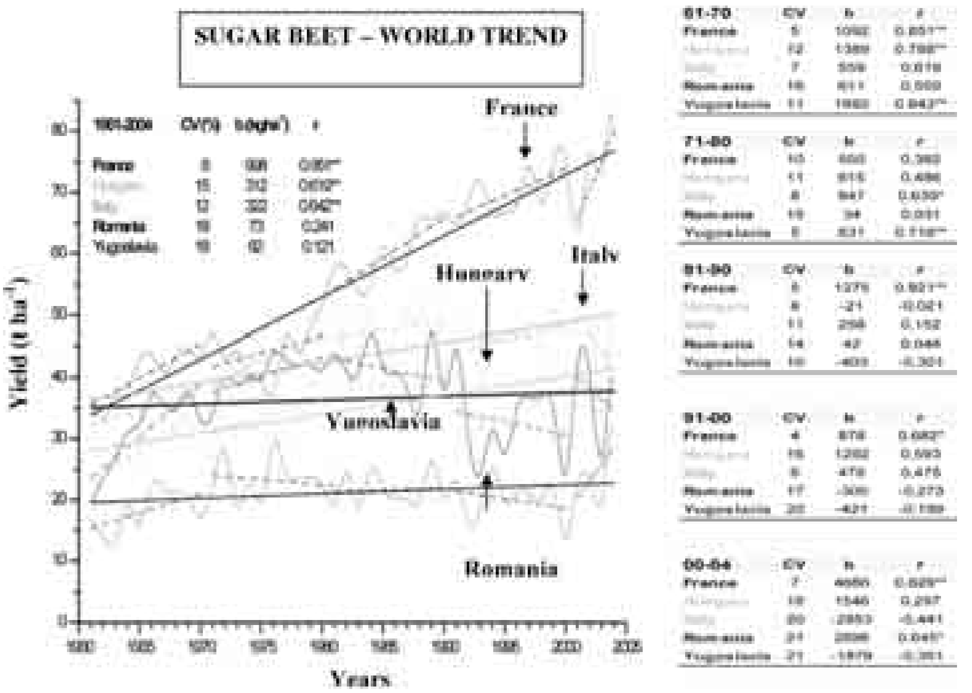
country, the growth rate of yield increase is 62 kgha^{-1}. The coefficient of yield variation from the trend line was 8% in France and 18% in our country.

At present, the average yields are above 70 tha^{-1} in France and between 30 and 40 tha^{-1} in our country. However, if we look back at the previous period, we can see significant differences. In 1961—1980 periods, yield growth rate was 1092 kgha^{-1} and 550 kgha^{-1} in France and 1692 kgha^{-1} and 631 kgha^{-1} in our country. The coefficient of yield variation in our country was higher than in France. In the following 20 years, sugar beet yields in France had a growth rate of 878—4666 kgha^{-1}. In Serbia and Montenegro during the same period, the yield had decreasing tendency, with an annual growth rate of 403—1879 kgha^{-1}.



Graph. 1 Sugar beet yield trend in period 1960—2004. (In the world)

MATERIAL AND METHODS

The study was conducted on a long-term stationary trial at Rimski Šančevi. The trial was established in 1964 on chernozem soil, with good physical, chemical and biological properties. The amounts of NPK nutrient then applied were 50, 100 and 150 kgha^{-1}. The fertilization treatments are triple nutrient combinations with a control treatment without fertilization. The rest of practical measures were standard for this plant species.

From the total amount of nutrient, 50% of nitrogen was applied in autumn, before plowing, while the rest of it was incorporated in summer, before pre-sowing tillage.

The effects of NPK nutrient on yield in production conditions were monitored. From 1993 to 2004, 62,419 ha were analyzed in the province of Vojvodina in total.

RESULTS

Fertilization of sugar beet is specific. It is a practical measure that significantly influences the yield. Fertilization is a measure that negatively effects the yield when there is a surplus or deficit of nutrients. Fertilization should help obtaining optimal and good quality yields. In the previous period, scientists believed that a surplus of phosphorus and potassium had no negative effects on yield. However, the latest studies have shown that all three nutrients have an equally negative effect on yield and quality, Marinković et al. (2000) obtained similar results.

Table 1. Root yield (tha^{-1}) at different levels of nitrogen, phosphorus and potassium fertilization (Average 1992—2004)

Fertilization variants	Root yield tha^{-1}
Control	32,65
N50 $K_2O_5$50 K_2O50	44,65
N50 $P_2O_5$100 K_2O50	44,22
N50 $P_2O_5$100 K_2O100	43,52
N100 $P_2O_5$50 K_2O50	43,82
N100 $P_2O_5$100 K_2O50	46,90
N100 $P_2O_5$100 K_2O100	45,75
N100 $P_2O_5$150 K_2O50	47,95
N100 $P_2O_5$150 K_2O150	45,47
N150 $P_2O_5$50 K_2O50	48,10
N150 $P_2O_5$100 K_2O50	49,06
N150 $P_2O_5$100 K_2O100	48,54
N150 $P_2O_5$150 K_2O100	47,95
N150 $P_2O_5$150 K_2O150	49,60
LSD 005	2,83

Table 1. shows the average root yield from the NPK trial. At the lower level of nitrogen fertilization (50 $kgha^{-1}$), the highest levels of P and K fertilization (100 $kgha^{-1}$ each) decreased root yield by 1 tha^{-1}. At the middle level of nitrogen fertilization (100 $kgha^{-1}$), increasing levels of P and K (more than 100 $kgha^{-1}$ P_2O_5 and more than 50 $kgha^{-1}$ K_2O) decreased the yield by 1,4 tha^{-1}. The same results were achieved with the high levels of nitrogen. In the treatment with 100 $kgha^{-1}$, the increase was 2,6 tha^{-1} and was not significant. Fertilization of sugar beet should be based on the results of N-min method and the

distribution of mineral nitrogen. The optimal amount of phosphorus for chernozem soil, at Rimski Šančevi is 50—100 kg P_2O_5. The optimal amounts of potassium for the same soil are about 50 kg K_2O. Intensive fertilization with P and K decreases sugar content (0,2—0,9%), sugar utilization (0,3—7,6%) and sugar yield (380—1060 $kgha^{-1}$).

The yield of 35 tha^{-1} is obtained at the level of 10mg of P_2O_5 per 100 g of soil (Al-method). At the level 10 to 20 mg (per 100 g of soil), yield increased up to 44,5 tha^{-1}. Further increasing of nutrients decreased the yield to 40,7 tha^{-1} (i.e. by 3,8 tha^{-1}). The coefficient of correlation between the phosphorus amounts in soil and yield is high and statistically significant (y = 59,7—0,672x r = –0,354*). Concerning potassium, the highest yield was at the level of 10 mg of K_2O per 100 g of soil (48,0 tha^{-1}). At 20 mg, the yield decreased to 45,5 tha^{-1} (–2,5 tha^{-1}, y = 54,6—0,710x r = –0,1929). More than 25 mg of K_2O produced yield decreases (42,6 tha^{-1}, y = 65,4—0,9240x r = –439*).

Shown in Table 2. are the results of the application of NPK amounts and yields achieved.

Table 2. Influence of NPK nutrition on root yield

	51—100 $kgha^{-1}$	101—150 $kgha^{-1}$	151—200 $kgha^{-1}$	201—250 $kgha^{-1}$	251—300 $kgha^{-1}$	301—350 $kgha^{-1}$
NPK	61,2	59,0	56,2	55,4	45,1	42,1
% area	0,1	12,1	10,5	22,4	26,3	15,3

Increase in NPK nutrients beyond 200 $kgha^{-1}$ decreased the yield by 0,8 tha^{-1}, 3,6 tha^{-1}, 5,8 tha^{-1}. With further increases in nutrient amounts, yield decrease continued.

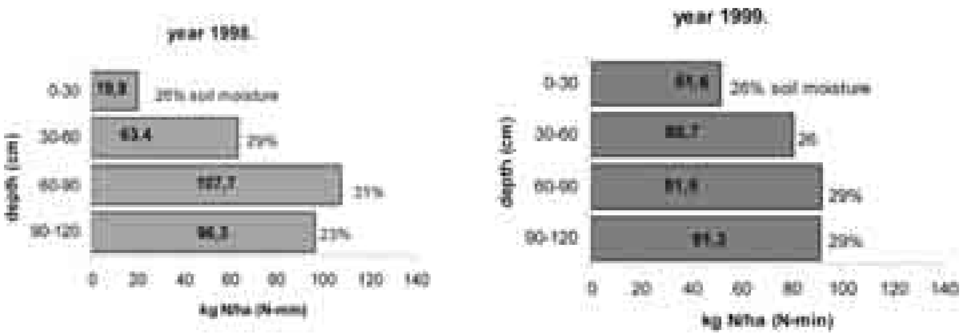
Sugar beet fertilization should be adapted to cultivar/hybrid demands, field potential and practical measures. The necessary nitrogen amounts should be determined with N-min method (Scharp and Verhman) and fertilization should be based on the balance method. Spring nitrogen amounts should be determined on the basis of the next equation:

$$Y = a \times b\ [(c + d) - e]$$

a — Planned yield (for cultivar, field, year)
b — Necessary nitrogen amounts (for 1t of root and adequate leaves and heads amounts)
c — Amount of mineral spring nitrogen in soil layer
d — Soil mineral ability
c — Nitrogen amounts at the end of vegetation

Planned yield should be determined for every cultivar/hybrid, for every field and year. Depth of humus accumulative horizon significantly influences field yield potential, relative to mineralization ability. Yield height will be defined by growing season precipitations and nitrogen distribution in soil profile (r = 0,315 for layer 30—60, r = 0,265 for layer 60—90).

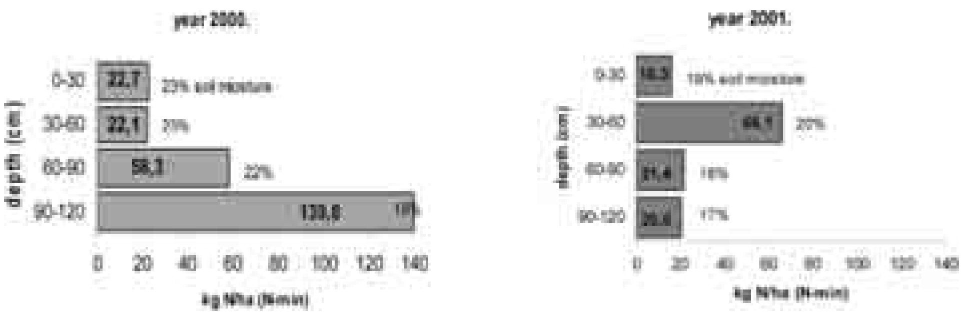
The level of significance in all cases is extremely high. With winter precipitation, it is 0,3% and at nitrogen it is 1,5 and 4,3%. Yield depends on actual evapo-transpiration in May, June and July. The main cause must be yield readjustment to the amount of growing season precipitations and nitrogen distribution in profile.



	Years	
	1998	1999
Growing season precipitation lm^{-2}	265	395
Vegetation rainfall lm^{-2}	491	542
ETP	591	591
ETR	531	542
Deficiency	61	44
Surplus	0	47 (IV; VI)
Root yield tha^{-1}	72,2	53,6
Sugar yield tha^{-1}	7,0	5,7

Graph. 2 Influence of nitrogen distribution in the soil profile and weather conditions on sugar beet root yield

These facts can be seen in Graphs 2. and 3. In Graph 2, yields from 1998 and 1999 are shown, as is nitrogen distribution and weather conditions. Based on the weather conditions, these two years are very similar. However, nitrogen distribution in 1998 was definitely more favorable and there was no precipitation surplus. Because of that, the root is better developed and guarantees better yield (72,2 tha^{-1}, as opposed 53,6 tha^{-1}). A dry period (deficiency 49 lm^{-2}) during the summer of 1999 apparently caused a decline in yield (18,6 tha^{-1}). Shown in Graph 3 are the same parameters for the years 2000 and 2001. The year 2001 had better weather conditions than the year 2000. Winter precipitations were 535 lm^{-2} higher, growing season precipitations by 105 lm^{-2}, actual evapo-transpiration by 236 lm^{-2} and potential evapo-transpiration by 51 lm^{-2}. Yield in 2001 was 39,3 tha^{-1} while in 2000 it was 33,5 tha^{-1} (higher for 5,8 tha^{-1}). Small yield in 2001 was affected by poor nitrogen distribution (high amounts in the layer at 30—60 cm depth) and excessive precipitation in April (80 lm^{-2}). Because of poor root development and nitrogen deficiency, precipitation deficiency (140 lm^{-2}) was decisive.



	Years	
	2000	2001
Growing season precipitation. lm^{-2}	148	683
Vegetation rainfall lm^{-2}	132	237
ETP	635	584
ETR	208	444
Deficiency	427	140
Surplus	0	239 (IV-80; VI-115)
Root yield tha^{-1}	33,5	39,3
Sugar yield tha^{-1}	4,4	4,4

Graph. 3. Influence of nitrogen distribution in the soil profile and weather conditions on sugar beet root yield

Many scientific papers have been written about the significance of fertilization (Šarić et al., 1993, Kastori et al., 1983, Marinković et al., 1993, 2000) For more than five years, Marinković et al. have been warning about the bad influence of excess of P and K.

Special attention should be paid to sugar beet fertilization. Fertilization must not be done without previous soil analysis. Knowledge and ability must be in accordance with field yield potential, prevailing conditions in a given year, cultivar/hybrid and the technology applied.

CONCLUSIONS

Based on trial and production results the following conclusions were made:

Increased amounts of phosphorus and potassium in trials resulted in yield increases of 1—1,4 tha^{-1}.

Fertilization with high amounts of NPK nutrients decreased sugar content (0,2—0,9%), sugar utilization (0,3—7,6%) and sugar yield (380—1060 $kgha^{-1}$).

In production conditions, the optimal level of phosphorus is 10—20 mg per 100g of soil, while the optimal level of potassium is 10 mg per 100 g of soil.

With lower phosphorus level in the soil, lower yield was obtained (by 9,5 tha^{-1}).

With the highest phosphorus content in the soil, root yield decreased by 3.8 tha^{-1}, while with the highest potassium content it decreased by 2,5 and 5,4 tha^{-1}.

Yield stability is secured when mineral nitrogen in spring is positioned at 30—90 cm depth.

With correct distribution of mineral nitrogen in the soil profile, the yield can be increased by 18,6 tha^{-1}.

Optimal and stabile yields can be achieved with fertilization based on cultural practice soil analyses.

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ЗНАЧАЈ АГРОТЕХНИКЕ И АГРОЕКОЛОШКИХ УСЛОВА ЗА ФОРМИРАЊЕ ПРИНОСА И КВАЛИТЕТА ШЕЋЕРНЕ РЕПЕ У ВОЈВОДИНИ

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Резиме

Принос биљака представља правилно усаглашене захтеве гајене биљке са агроеколошким условима региона.

Ђубрењем шећерне репе праве се највеће грешке и код ове агротехничке мере највећи су губици.

Посматрано у целини за NPK хранива, у производним условима, због недостатка хранива губици су од 2,1 до 14,9 tha^{-1}, а због сувишка хранива смањење приноса је од 5,8 до 18,9 tha^{-1}. Губици у квалитету корена су такође значајни. Смањење садржаја шећера варира од 0,2 до 0,9%, искоришћење шећера од 0,3 до 7,6% и укупан губитак шећера од 380 до 1060 kgha^{-1}.

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STUDY OF SUGAR BEET VIRUSES TRANSMITTED BY *POLYMYXA BETAE* IN THE CZECH REPUBLIC*

ABSTRACT: Sugar beet viruses transmitted by *Polymyxa betae* are very widespread in the Czech Republic. *Beet soil-borne virus* (BSBV) is present in almost all fields used for sugar beet growing, *beet virus Q* (BVQ) is present in about 50% of fields but *beet necrotic yellow vein virus* (BNYVV) is present in some limited regions only. It means that mixed infections of sugar beet by at least two viruses are quite common in the field. *P. betae* also occurs in almost all fields where sugar beet is now grown. Only two populations of *P. betae* not transmitting any virus were found. Cystosori of *P. betae* can harbour viruses without loosing infectivity for a very long time. We were able to detect these viruses in plants grown in soil stored dry for 12 years. BNYVV can cause serious yield losses under mideuropean conditions reaching up to 50% of sugar yield, whereas harmfulness BSBV and BVQ is questionable, because they also occur in fields with no problems concerning sugar beet growing. The host range of these viruses was studied. Both infect all types of beet (sugar, fodder, red beet, mangold) and spinach and usually are detectable in root system only. Other chenopodiaceous plants are infected only by some virus strains. These strains are also able to spread into above-ground parts of plants.

KEY WORDS: sugar beet, *Polymyxa betae*, beet soil-borne virus, beet virus Q, beet necrotic yellow vein virus

INTRODUCTION

BNYVV causes serious disease of sugar beet, rhizomania. It was originally described in Italy (Canova, 1959) but now it is present in sugar beet areas all over the world (Asher and Dewar, 1999). Losses can reach more than 50% of root yield. Sugar content is usually substantially decreased as well as sugar extractability because of higher content of alkaline elements (Heijbroek, 1989). Its presence in the Czech Republic was first confirmed in 1993 (Konecny, 1994).

* The paper was presented at the first scientific meeting IV INTERNATIONAL SYMPOSIUM ON SUGAR BEET Protection held from 26—28 september 2005 in Novi Sad.

BSBV was first found by I v a n o v i č and M c F a r l a n e (1982) in England and further described by H e n r y et al. (1986). It is widespread in sugar beet growing areas all over the world (P r i l l w i t z and S c h l o s s e r (1992), L i n d s t e n (1991), T u r i n a et al. (1996). The virus is transmitted by soil protist *Polymyxa betae* (I v a n o v i č et al., 1983) and meets the criteria to be included into genus *Pomovirus* (H u l l, 2002). The host range of BSBV was studied by H e n r y et al. (1986) using mechanical inoculation of leaves of tested plant species. BSBV can probably spread systemically in certain hosts after mechanical inoculation but no data are available concerning host range and spreading in plants after natural transmission by *P. betae*. BSBV was reported to reduce fresh weight of young plants (K a u f m a n n et al., 1993) and to increase losses caused by BNYVV in pot experiments. Nevertheless, no data are available about direct losses in field conditions.

BVQ was originally considered to be a serologically distinct strain from BSBV, but finally K o e n i g (1998) proved its different RNA composition substantiating its separation from BSBV. The host range of BVQ is supposed to be similar to that of BSBV but in fact no data are available. The situation is the same concerning knowledge about BVQ distribution in infected plants.

MATERIALS AND METHODS

Survey of soil-borne viruses

100 soil samples were taken from fields where sugar beet is really grown, including the fields with rhizomania occurrence in the past and with no problems concerning sugar beet growing. Altogether, about 5 kilograms of soil was taken on several sites from each field. Sugar beet baiting plants (cv. Steffi) were sown into pots with soil samples, those were placed into climatized room, exposed to 16 hours of light (22°C) and 8 hours of dark (18°C). After six weeks, roots of baiting plants were harvested, washed and examined by optical microscope for the presence of cystosori of *P. betae*. If they were found, roots were tested for the presence of viruses. If not, plants were harvested and examined after additional two weeks. Some soil samples taken 12 years ago and stored dry at naturally changing temperature were also retested.

Detection of viruses

The testing of baiting plants for the presence of BNYVV was done by ELISA test using antibodies from Loewe Biochemica. BSBV was tested using antibodies from prof Lindsten (Uppsala, Sweden) and from DSMZ Braunschweig and BVQ by antibodies from Braunschweig. All these tests were performed according to the protocols provided by manufacturers of antibodies. Moreover, both BSBV and BVQ were tested by RT PCR as described by Z o u h a r et al. (2000).

Studies of host range and spreading of viruses in plants

From all soil samples, three (A, B, C), containing both BSBV and BVQ were further used for host range studies. Baiting plants of different species from the families *Chenopodiacea*e, *Caryophyllaceae* and *Amaranthaceae* were sown into soil and their roots were subsequently tested by RT PCR as described above. If viruses were confirmed in roots, hypocotyls and leaves were also tested. Positive results from RT PCR were confirmed by mechanical inoculation of *Chenopodium quinoa* leaves using HEPES buffer, pH 7.5 containing 5% of polyvinylpyrrolidone. Local lesions from *C. quinoa* leaves were also tested by RT PCR and subsequent mechanical passages on *C. quinoa* leaves were made.

RESULTS

Survey of soil-borne viruses

Cystosori of *P. betae* were found in all but 2 soil samples taken during the survey. BSBV was proved to be very widespread as it was present in 96 samples. BVQ was confirmed in 48 samples, mostly together with BSBV. Only one sample contained BVQ alone. BNYVV was confirmed in only 20 samples from fields where it had already been confirmed by State Phytosanitary Administration. This means that in some samples, sugar beet is infested by two, sometimes by three viruses (all BNYVV containing samples). Both BSBV and BVQ were readily detected in baiting plants from samples taken 12 years ago.

Host range

In soil samples A and B, all varieties of sugar (8), red (3), fodder (3) beet, spinach (15) and mangold (3) were infected by BSBV and BVQ. Both viruses were confined to roots only. No other species were infected (*Beta patellaris, Chenopodium album, C. amaranthicolor, C. bonus-henricus, C. ficifolium, C. foetidum, C. hybridum, C. murale, C. polyspermum, C. quinoa, C. ugandae, C. urbicum, C. vulvaria, Amaranthus blitoides, A. lividus, A. retroflexus, A. tricolor, Atriplex lampa, A. calotheca A. hortensis, A. procera, A. sagittata, Celosia argentea, C. cristata, Tetragonia expansa*).

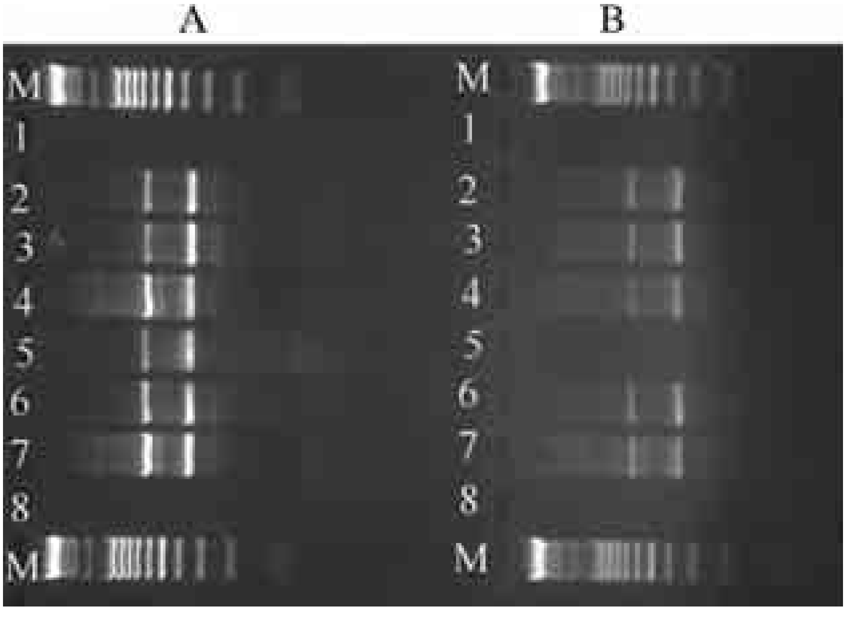
In sample C, some species apart from beets and spinach were also infected. *C. vulvaria* was infected by both BSBV and BVQ, whereas *C. murale* was infected by BSBV only. *C. quinoa* was sometimes infected by BSBV and sometimes by BVQ only (Figure 1).

M Markers
1. Negative control
2. Positive control of BSBV and BVQ
3. *C. quinoa*
4. *C. vulvaria*
5. *C. album*
6. *C. urbicum*
7. *C. murale*
8. *Amaranthus tricolor*
9. *Spinacia oleracea*
10. *A. blitoides*

Fig 1. Host range testing of roots of baiting plants by RT-PCR

Spreading of viruses in plants

In samples A and B, BSBV and BVQ have never been confirmed in above-ground parts. On the contrary, in sample C, viruses were also present in hypocotyl and leaves of sugar beet, spinach and *C. vulvaria* as revealed by RT PCR (Figure 2) and for BSBV, also proved by mechanical inoculation of *C. quinoa* leaves. When local lesions were tested by RT PCR, only BSBV was proved. After mechanical inoculation of *C. quinoa* leaves from systemically infected material, mainly rather compact chlorotic and later necrotic local lesions formed (Figure 3). After subsequent passage, mainly vein banding with some necrotization appeared (Figure 4).



	A	B
M	Markers	
1.	Negative control	
2.	Positive control of BSBV and BVQ	
3.	Lambada roots	San Marco roots
4.	Lambada hypocotyl	San Marco hypocotyl
5.	Lambada leaves	San Marco leaves
6.	Carambole roots	Matador roots
7.	Carambole hypocotyl	Matador hypocotyl
8.	Carambole leaves	Matador leaves

Fig. 2. Results of testing of spinach varieties by RT-PCR

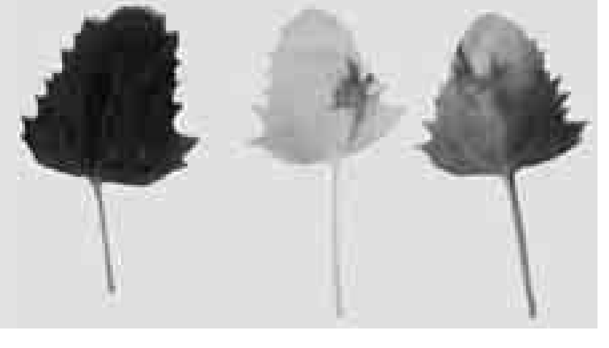


Fig. 3. BSBV local lesions on *C. quinoa* plants after mechanical inoculation with homogenate from sugar beet roots. Healthy leaf on the left

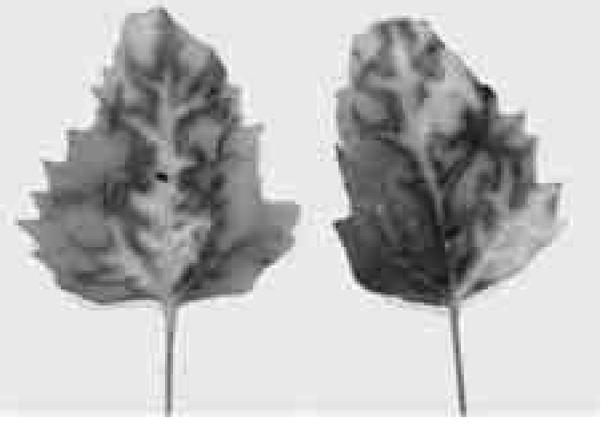


Fig. 4. Vein banding on *C. quinoa* plants after subsequent mechanical inoculation with homogenate from local lesions

DISCUSSION

Our survey of soil-borne viruses of sugar beet in the Czech Republic revealed that *Polymyxa betae*, as a vector of some soil-borne viruses is present in almost all fields where sugar beet is grown. BSBV is almost omnipresent, as well. This is in agreement with some studies in other countries like Belgium and Italy (Legreve et al., in press; Rubies Autonell et al., in press). At the same time, it becomes evident that the impact of this virus on sugar beet yield is rather low, if any, because it occurs on fields with no problems concerning sugar beet growing, even when some interactions with other viruses, mainly BNYVV also appear. BNYVV is present in some, until now restricted areas in the Czech Republic (east of Prague and mainly Central Moravia). Long-term ability of *P. betae* to harbour viruses it transmits was confirmed as both BSBV and BVQ were detected in samples taken 12 years ago.

BSBV and BVQ are generally able to infect naturally sugar, red, fodder beet, mangold and also spinach. It seems that some strains only are also able to infect other chenopodiaceous species like *C. vulvaria, C. quinoa* and *C. murale*. According to Henry et al. (1986) *C. album, C. amaranthicolor, C. foetidum, C. murale, C. polyspermum* and *C. quinoa* can be infected by mechanical inoculation of leaves. However, from these species only *C. quinoa* and *C. murale* were infected by *P. betae* zoospores in our experiments. Some of them are not infected by *P. betae* at all, others, like *C. album*, may be immune to infection via roots or the concrete forma speciales of *P. betae* is not able to transmit the viruses. At the same time, these virus strains are also able to spread into above-ground parts of plants. Further studies are needed to discover the reason(s) for these differences. Another interesting thing is the change of the character of symptoms caused by BSBV between the first and second passage on *C. quinoa* leaves. Maybe, there are some deletions in virus RNA that are causing this change of symptoms and finally loss of infectivity as it is known from the case of BNYVV (Bouzobaa et al., 1991).

ACKNOWLEDGMENTS

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ПРОУЧАВАЊЕ ВИРУСА ШЕЋЕРНЕ РЕПЕ КОЈЕ ПРЕНОСИ *POLIMYXA BETAE* У ЧЕШКОЈ РЕПУБЛИЦИ

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Резиме

Вируси шећерне репе које преноси *Polymyxa betae* су у Чешкој Републици широко распрострањени. *Вирус шећерне репе који се преноси земљиштем* (BSBV) је присутан у скоро свим пољима где се шећерна репа гаји, *Q вирус шећерне репе* (BVQ) је заступљен на око 50% поља, док је *вирус некритичног жутила нерава шећерне репе* (BNYVV) присутан само у неким, ограниченим областима. То значи да су мешовите заразе шећерне репе са бар два вируса уобичајене у пољу. *P. betae* се појављује и у скоро свим пољима на којима се шећерна репа сада гаји. Нашли смо само две популације *P. betae* које не преносе ни један вирус. Cistosorusi *P. betae* могу да садрже вирусе који инфективност не губе током веома дугог временског периода. Били смо у могућности да откријемо ове вирусе у биљкама узгајаним у земљи, ускладиштеним на сувом током 12 година. BNYVV може да проузрокује озбиљне губитке у приносу у условима средње Европе, који достижу до 50% губитка приноса шећера. Штетност BSBV и BVQ је под знаком питања јер се они појављују и на пољима на којима нема проблема код узгоја шећерне репе. Развијен је PCR метод за откривање и диференцијацију BSBV и BVQ у једној реакцији. Проучаван је круг домаћина ових вируса. Оба заражавају углавном све типове репе (шећерне, сточне, црвене) и спанаћа и обично се могу открити само у кореновом систему. Друге биљке из фамилије *Chenopodiaceae* су заражене само неким сојевима вируса. Ови сојеви могу да се прошире и на надземне делове биљке. Електронска микроскопија, уз помоћ метода обележавања антитела златом, открила је да се BSBV појављује у лисном ткиву механички инокулисане *Chenopodium quinoa* у карактеристичним инклузијама формираним од неколико честица поређаних једна поред друге. Без обзира на то, до сада у ткиву корена нисмо успели да их нађемо.

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THE MOST IMPORTANT PATHOGENS TRANSMITTED BY SUGAR BEET*

ABSTRACT: Pathogenic fungi and viruses transmitted by sugar beet seed represent a complex group of organisms. Detection of these pathogens is an important issue in sugar beet protection. Their identification is a difficult task because the most available methods rely on the growth characteristics, morphological and biochemical criteria. Three domestic and eight foreign sugar beet varieties, from Germany, Italy and Greece were included in the investigation. Seed health testing was performed in laboratory and in field conditions. During the trials, the following methods were used: blotter method, agar plate method and ELISA test for viruses. Seeds were incubated in "Conviron" aparatus at 22°C which is suitable for sporulation of different kind of fungi (light and temperature were adjustable). The appereance of following fungi was noted during incubation: *Pleospora bjoerlingii* (*Phoma betae*), *Fusarium* spp., *Pythium* spp. *Aphanomyces cochlioides* and *Cercospora beticola*. Viruses tested by ELISA test were *beet necrotic yellow vein virus* (BNYVV) and *beet yellows virus* (BYV). Viruses were tested in sugar beet seedlings grown in laboratory conditions and on leaves of individual plants from the field. The disease index was calculated on the basis of intensity of infection of plants for *Cercospora beticola* and *Phoma betae* according to Mc Kinney's formula. Results were presented by graphs, tables and original photos.

KEY WORDS: ELISA test, leasf spot, seed-borne, sugar beet, diseases, viruses

INTRODUCTION

More than 90% of food in the world is produced from the seed. Seed itself often presents the basic source of parasite inoculum. The reasons for giving such attention to pathogens are ever more increasing exchange of seed material and the danger of spreading of new pathogens to those parts of the world where they were not found previously. The exchange of seed material contributed to increased number of seed-borne pathogens. Viruses found in field and vegetable crops only recently gained importance. Economic impor-

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tance of seed-borne parasites led to altered attitude of developed countries towards phytopathology and the seed-borne pathogens. Now, special attention is paid to problems related to quarantine, seed quality determination and chemical protection. Seed certification has become the part of integral management system in plant protection (M i l o š e v i ć, 2001).

Regular control of seed health on the presence of quarantine and economically harmful organisms, in the laboratory and in the quarantine field is necessary due to the increased import of sugar beet seed from different parts of the world. Continual quarantine and post-quarantine supervision is the basis for well developed and stable production as well as for the protection of domestic varieties from uncontrolled import.

Sugar beet seed plays an important role in seed certification scheme. Due to economic importance of this plant species, it is important to be familiar with harmful organisms attacking its seed. The most common sugar beet seed-borne parasites are *Pleospora bjoerlingii* B y f o r d (an. *Phoma betae* B j o e r l i n g) — *Phoma leaf spot* and *damping off*; *Peronospora farinosa* (Fr.) Fr. f. sp. *betae* B y f — *downy mildew*; *Cercospora beticola* S a c c. — *Cercospora leaf spot*; *Ramularia beticola* F a u t r. et L a m b. — *Ramularia leaf spot*; *Uromyces betae* (P e r s.) L e v. — *sugar beet rust*; *Alternaria tenuis* N e e s. — *Alternaria leaf spot*; *Fusarium oxysporum* — *Fusarium yellows*; *beet necrotic yellow vein virus* (BNYVV); *beet yellows virus* (BYV).

Beet necrotic yellow vein virus is a quarantine parasite listed on the A2 EPPO list No. 160 (OEPP/EPPO, 1988). It is also listed in Rules on health examination of crops and objects for production of seed, seedlings and planting material and health examination of seed, seedling and planting material (*Official register of SRJ*, 66/99). *Beet yellows virus*, *Peronospora farinosa* and *Phoma betae* are also listed as economically significant parasites.

Effective protection of crops from those above mentioned diseases could be achived by complex mesaures in which cultivation practice, the introduction of tolerant varieties into production and the application of fungicides are included (M a r i ć and J e v t i ć, 2001).

MATERIAL AND METHODS

The appearance of quarantine and economically harmful parasites of sugar beet on domestic and foreign varieties was observed. Three domestic and eight foreign sugar beet varieties from Germany, Italy and Greece were included in the investigation. Domestic varieties were marked as S1, S2 and S3; those from Germany as N1, N2, N3 and N4; those from Italy as I1, I2 and from Greece as G1 and G2. Testing was done both in the field and in the laboratory.

Laboratory testing

Seed health testing was done in laboratory conditions in the National laboratory for seed testing as a part of regular testing of samples from domestic trade and import. Blotter method, method of nutritive media and ELISA test were used as laboratory tests.

Pelleted seed was previously washed in order to remove preparation and initiate the development of seed-borne parasites. The seed for testing on blotter and nutritive media were initially prepared by immersing in 1% NaOCl solution for 5 minutes. After that, the seed was washed (3 times) in sterile water, dried and placed into previously prepared Petri dishes. Ten seeds, from 400 were placed into each Petri dish. The incubation of seed on blotter and potato dextrose agar was done in sterile conditions in Petri dishes for 7 days at 22°C (ISTA Rules, 2002) using alternating light cycle (12h NUV/12h of dark, "Conviron" apparatus). Upon incubation, each seed was observed under a stereo microscope and present pathogens were determined (M a t h u r and K o n g s d a l, 2003).

Viruses were identified using serological method (Enzyme immuno-adsorbtion ELISA test). Samples were tested in two stages. In the first stage, the seed was germinated in sterile boxes and ELISA test was done using obtained sugar beet seedlings. In the second stage, the samples of leaves from field were used. Forty-five seedlings from one variety and 45 leaves from individual plants were tested for both viruses.

Table 1. — ELISA test for BNYVV and BYV

Procedure	Reagent	Time of incubation	Incubation temperature	Number of washing
Incubation of the antybody (NUNC-96 plates)	IgG dilution 1:200 in coating buffer	4 h	37°C	4x
Forming of the antibody-antigen complex	Extraction of samples (seedling) in buffer-relation 1:20	Over night	4°C	5x
Application of the antibody AP-conjugate	AP-conjugate diluted 1:200 in extraction buffer	4 h	37°C	5x
Enzymic assay	Substrate solution	1—2 h	Room temperature	—

Reagents of *beet necrotic yellow vein virus* BNYVV and *beet yellows virus* (BYV) (LOEWE Biochemica GmbH, Germany), Kit Complete consisting of antibody, conjugate, positive and negative control were used. Automatic ELISA reader, Multiskan Ascent at 405 nm was used for reading of Nunc plates with 96 wells.

Field testing

The survey was conducted in 2005 at Rimski Šančevi testing field 1 (quarantine field of National laboratory for seed testing). Chosen varieties were sawn in the first part of April (2005-04-04). Each sample was sawn in two rows using sawing machine for micro trials. Rows were 10 m in length with 70 cm distance between the rows. Fungicide treatments were not used during vegetation period. Disease intensity was evaluated by exemination of individual plants (each fifth plant) according to scale of 0—9. Disease index was calculated on the basis of the intensity of leaf spot diseases according to Mc Kinney's formula.

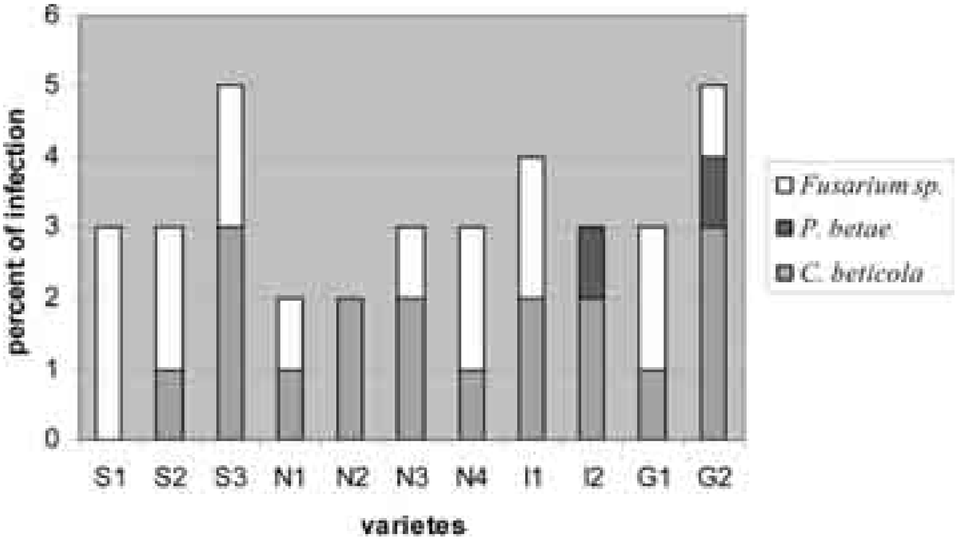
$$I = \frac{\sum (axb)}{kx10} x100$$

I — disease index
a — number of exeminated plants
b — number of categories (0—9)
k — total number of plants
10 — number of categories

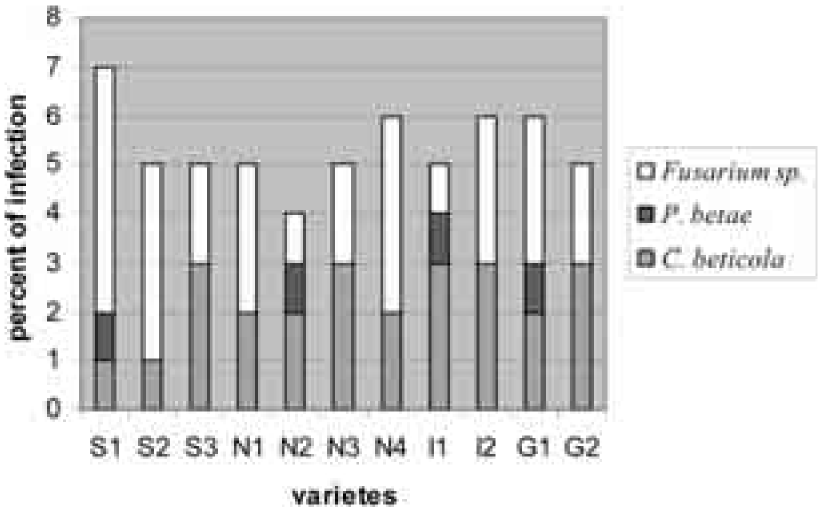
RESULTS

Results of laboratory testing

Results of laboratory testing on blotter and nutritive media are shown in graphs 1 and 2. Total percentage of seed infection ranged from 2—5% on blotter, and from 4—7% on nutritive media. *Aphanomyces cochlioides* and *Pythium* sp. were not found in sugar beet samples.



Graph. 1 — Percentage of sugar beet infection caused by *Fusarium* sp., *Phoma betae* and *Cercospora beticola* on blotter



Graph. 2 — Percentage of sugar beet seed infection caused by *Fusarium* sp., *Phoma betae* and *Cercospora beticola* on nutritive media (PDA)

According to obtained results of ELISA test (Table 2) for sugar beet seedlings, all tested samples were healthy.

Table 2 — Range of absorption values obtained by DAS ELISA test for *beet necrotic yellow vein virus* (BNYV) and *beet yellows virus* (BYV) (from seedlings)

Variety	Beet necrotic yellow vein virus (BNYV)	Beet yellows virus (BYV)
S1	0,074—0,092	0,055—0,111
S2	0,072—0,137	0,041—0,131
S3	0,093—0,134	0,043—0,132
N1	0,076—0,127	0,052—0,121
N2	0,076—0,116	0,051—0,109
N3	0,089—0,133	0,062—0,100
N4	0,083—0,134	0,044—0,110
I1	0,085—0,125	0,055—0,121
I2	0,070—0,122	0,066—0,133
G1	0,072—0,124	0,067—0,119
G2	0,072—0,103	0,058—0,128
Positive control	1,295	0,768
Negative control	0,137	0,118

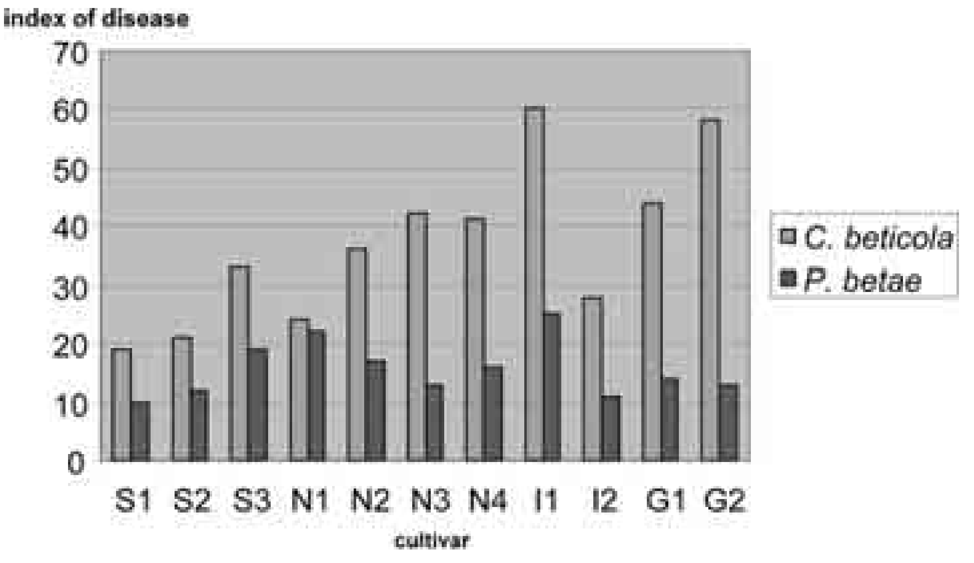
Results of laboratory testing

According to ELISA test (Table 3) results obtained from sugar beet leaves, all tested samples were healthy.

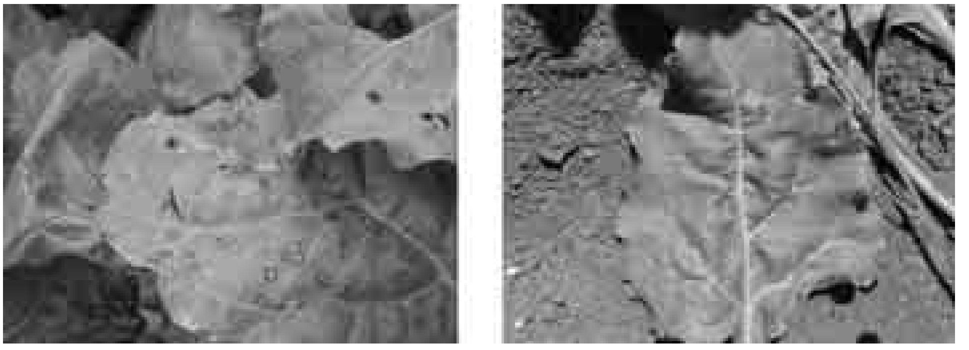
Table 3 — Range of absorption values obtained by DAS ELISA test for *beet necrotic yellow vein virus* (BNYV) and *beet yellows virus* (BYV) (from leaves of individual plants from field)

Variety	beet necrotic yellow vein virus (BNYV) (rhizomania) (BNYV)	beet yellows virus (BYV)
S1	0,081—0,103	0,083—0,103
S2	0,086—0,098	0,089—0,098
S3	0,099—0,112	0,089—0,112
N1	0,101—0,129	0,110—0,129
N2	0,123—0,135	0,111—0,125
N3	0,078—0,141	0,088—0,121
N4	0,085—0,138	0,086—0,118
I1	0,111—0,139	0,101—0,124
I2	0,127—0,130	0,066—0,115
G1	0,106—0,145	0,076—0,125
G2	0,110—0,132	0,100—0,128
Positive control	1,301	0,833
Negative control	0,150	0,121

The high percentage of infection caused by *Cercospora beticola* ranging from 19—60% was noticed based on the results of index of diseases (Graph. 3), while *Phoma betae* was present in much smaller percentage, from 10—25%



Graph 3 — Index of diseases according to Mc Kinney's formula for causal agents of *beet leaf spot*



Symptoms of *sugar beet leaf spot* (*Cercospora beticola* and *Phoma betae*) are shown on figure 1 and 2. *C. beticola* causes appearance of tiny, round, grey spots with dark red tissue zone on the edge of sugar beet leaf (Figure 1). *P. betae* forms large round concentrically zoned spots, often with cracked tissue in the centre (Figure 2).

DISCUSSION

Sugar beet seed health testing (blotter and nutritive media) revealed the presence of parasitic fungi *Phoma betae* and *Cercospora beticola*, and fungi from *Fusarium* genus. Total percentage of infection ranged from 2—5%. From obtained results, it can be seen that *Fusarium* was present on most of the varieties except on N2 and I2. *Phoma betae* was found on two tested varieties: I2 and G2 and the percentage of infection did not exceed 1%. *Cercospora beticola* was not found in domestic variety S1 and the percentage of infection in other varieties ranged from 1—3%.

Nutritive media method revealed the presence of seed parasites in approximately the same percentage as in the method on blotter. Obtained percentage of infection is the result of chemical treatment (pelleted seed) and does not significantly influence disease level on plants in the field (Richardson, 1990).

According to results obtained by ELISA automatic reader at 405 nm, all tested seed samples (seedlings) were negative for both BYV and BNYV, which was also confirmed by comparison of obtained values with positive and negative controls. ELISA test is used as one of serological procedures for pathogen identification. This method is a modern technique in seed health testing (Machado et al., 2002). High reliability and speed of pathogen detection are major elements in many areas where efficient and precise analyses and results presentation is needed. This method is recommended as an efficient and reliable for determination of latent infections when import consignments are in question. This is especially significant since the possibility of transmission of *beet yellows virus* by seed is mentioned in the literature (Neergaard, 1979). It is also known that virus of *rhizomania* can be indirectly transmitted by seeds coated with residues of infected beet or soil parts (Šutić, 1995). In spite of different opinions on seed virus transmission, those in charge of sugar beet import should check the seed on the presence of *beet yellows virus* and *beet necrotic yellow vein virus* in a laboratory and check crops prior to main aphids flight in the field (group of authors, 1980).

ELISA test was also used for samples of individual plants from the field (parts of leaf were taken). Viruses were not found in analyzed samples. Concentration of viruses is usually very unequal and content of viruses and their concentration is higher in older leaves (A g r i o s, 1997). *Beet necrotic yellow vein virus* and *beet yellows virus* are mainly found in phloem, although they can be found in other plant parts too (leaf) (Š u t i ć, 1995). These viruses can be transmitted during vegetation period from overwintered infection sources, such as some weeds, mangel or fodder rape pits, self seeded plants etc. Virus vectors are aphids *Myzus persicae* and *Aphis fabae*. Intensity of infection depends on density of aphid population and sources of infection, especially those close to sugar beet field.

Field trials were observed during vegetation period. Seedling decline was not found in the stage of sugar beet emergence due to fungicide treatment (pelleted seed). Mini-pelleting and pelleting of sugar beet seed is a technological procedure in seed processing when seed is covered with several different micro and macro substances, growth stimulators, fungicides and insecticides (K a w a k a t s u et al., 1998).

Meteorological conditions during vegetation period and especially quantity and schedule of precipitation influenced intensity of appearance of leaf diseases during 2005. No chemical fungicide treatment was used during sugar beet vegetation period. Sugar beet in isolation was sown on the bordering plot (0,1 ha) in the previous year (2003/04) which could be the source of initial parasite inoculum. High percentage of appearance of leaf diseases is the result of combination of above mentioned factors. The greatest values of disease index for *Cercospora beticola* (60%) were found for I1 and G2 varieties, while the smallest index was found for domestic varieties S1 and S2 (20%). *Phoma betae* was found in much lesser percentage, ranging from 10—25%.

Optimal conditions for plant infection are temperature at around 25°C and relative humidity exceeding 95%. By cultivating tolerant variety and using regular agrotechnical measures and chemical protection, the intensity of appearance of sugar beet leaf diseases is decreased. Infected seed could be a potential source of inoculum, but infected residual debris, poor agrotechnical measures and irregular crop rotations make even greater threat. Infected leaves left on field are the most significant source of infection, so regular crop rotation has great influence on disease development.

Regular expert seed health control related to quarantine and economically harmful organisms, done in the acredited laboratories is the basis for high and stable yields besides proper agricultural measures and the application of chemical preparations.

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ЕКОНОМСКИ НАЈЗНАЧАЈНИЈИ ПАРАЗИТИ КОЈИ СЕ ПРЕНОСЕ СЕМЕНОМ ШЕЋЕРНЕ РЕПЕ

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Резиме

Патогене гљиве и вируси који се преносе семеном шећерне репе представљају комплексну групу организама. Испитивање ових патогена је веома значајно у заштити шећерне репе. Њихова идентификација је доста сложена због тога што се многе доступне методе односе на карактеристике пораста, морфолошке и биохемијске особине. У испитивања су биле укључене три домаће и осам страних сорти шећерне репе пореклом из Немачке, Италије и Грчке. Огледи су изведени у лабораторији и у пољу. Здравствено стање семена одређивано је у лабораторијским условима. У току рада коришћене су следеће методе: филтер папир метод, метод хранљиве подлоге и ELISA тест на присуство вируса. Семе је инкубирано у термостатима на 22°C и у „Conviron" апарату где постоји могућност

подешавања светлости и температуре, потребних за спорулацију различитих гљива. Током инкубације праћена је појава следећих паразитних гљива: *Pleospora bjoerlingii* (*Phoma betae*), *Fusarium* spp., *Pythium* spp., *Aphanomyces cochlioides* и *Cercospora beticola*. Вируси су испитивани ELISA тестом и то: Вирус некротичног жутила нерава шећерне репе (Beet necrotic yellow vein virus BNYVV) и Вирус жутице шећерне репе (Beet yellows virus BYV). Вируси су анализирани из поника добијених наклијавањем у лабораторијским условима и из листа појединачних биљака у пољу. На основу интензитета заразе биљака у пољу израчунат је индекс обољења за гљиве *Cercospora beticola* и *Phoma betae* према Mc Kinney-евој формули. Добијени резултати представљени су графиконима, табелама и оригиналним фотографијама.

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ROOT ROT OF SUGAR BEET IN THE VOJVODINA PROVINCE*

ABSTRACT: Large changes introduced in the sugar beet production technology in the Vojvodina Province over last 40 years resulted in changes in the etiology and harmfulness of different agents of sugar beet root diseases. Improvements in cultivation practices reduced the harmfulness of some diseases while increased the harmfulness of others. Some disease agents became obsolete, but others gained importance. New agents of root diseases were found. The most frequent damages, persisting over long periods of time were caused by seedling damping-off, *Fusarium* root rot, charcoal root rot, parasitic (*Rhizomania*) and non-parasitic root bearding. The parasitic damping-off, caused by several fungal species but most frequently by *Phoma betae* occurred at the time when multigerm seeds were used in combination with extensive cultural practices. The agents of seedling diseases completely lost their significance as the consequence of switching to fungicide — treated monogerm seeds, earlier planting and improved soil tillage. In the period of intensive use of agricultural chemicals, seedling damping-off occurred frequently due to the phytotoxic action of chemicals (insecticides, herbicides and mineral fertilizers). In some years, frosts caused damping-off of sugar beet seedlings on a large scale in the Vojvodina Province. Poor sugar beet germination and emergence were frequently due to spring droughts. Sometimes, they were due to strong winds. The occurrence of *Fusarium* root rot and charcoal root rot intensified on poor soils. Fusariosis symptoms were exhibited as plant wilting and different forms of root rot. In recent years, root tip rot has occurred frequently in the first part of the growing season, causing necrosis and dying of plants. Lateral roots tended to proliferate from the healthy tissue, giving the root a bearded appearance similar to *Rhizomania*. *Fusarium oxysporum* was the most frequent agent of this fusariosis. *F. graminearum, F. equiseti, F. solani* have also been identified in recent years as the agent of root rot, but its importance was much lower. Charcoal root rot and plant wilting (*Macrophomina phaseolina*) have caused extensive damages in sugar beets, especially under the conditions of severe drought and high temperatures in summer. In some years, it was the dominant agent of root rot. Mixed infections caused by fungi from the genera *Fusarium* and *M. phaseolina* were encountered frequently. The extent of damage caused by these diseases was reduced by improved pro-

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duction technology. *Rhizomania* of sugar beet (caused by *beet necrotic yellow vein virus*) was identified in Serbia in the 1970s. Results of recent investigations have shown that BNYVV is widespread in Vojvodina, since the virus was found on 36,7% (24,674 ha) of acreages from 67,213 ha of total sugar beet acreages inspected on incidence of BNYVV in the period from 1997 to 2004 year. In the last few years, the occurrence of *Rhizoctonia* root rot (*Rhizoctonia solani*) was registered in some localities in Vojvodina.

KEY WORD: BNYVV, charcoal rot, etiology, *Fusarium* spp., root rot, *Macrophomina phaseolina*, sugar beet, Vojvodina

INTRODUCTION

In the last four decades, great changes occurred in sugar beet production in Vojvodina. New processing capacities were built and the areas covered with sugar beet greatly increased. Sugar beet production spread onto unfavorable, arid areas as well as on the areas characterized by poor soil conditions. The technology of sugar beet production was constantly changing. Great amounts of chemical substances were used and at one point, their uncontrollable application in agricultural production was observed. Great amounts of mineral fertilizers, soil insecticides and herbicides were applied into the soil surface. Crop rotation was narrowed, thus, beet was often cultivated in two-crop rotation. Due to such conditions, different sugar beet diseases occurred, which in some cases, significantly influenced the yield and the quality of the product (Marić and Stojšin, 2004).

MATERIALS AND METHODS

Collecting root samples

Sugar beet root rot was observed in several localities in Vojvodina and was monitored during the period of vegetation from 1998 to 2004. In order to determine and identify the agents of root rot and to study disease symptoms, root samples characterized by rot symptoms were collected from several different localities. Roots were randomly chosen and the part of roots with characteristic disease symptoms were used for isolating and determining the parasites, causal agents of rot.

Fungi isolation

Fythopathological isolations were conducted in standard way in Petri dishes on nutritive potato-decstrose agar medium and then incubated at 25°C for fungi isolation. After the colonies had been developed, transplantation of isolates was conducted in order to achieve pure cultures and determine the fungi.

Fungi determination

Pure fungi cultures belonging to *Fusarium* genus were transplanted onto the carnation medium (CLA) and exposed to special light, so called "black light", in order to trigger fructification. On the basis of fungi colony appearance, conidia and conidiophores as well as on the basis of chlamydospore creation, the determination of species was conducted (N e l s o n et al., 1983, B u r g e s s et al., 1988, 1991).

Based on the morphological characteristics of vegetative and reproductive organs, all other fungi species were determined (W h i t n e y and D u f f u s, 1989).

The investigation of NPK fertilization influence on the occurrence of root rot and bearded root were conducted on the fields of Research Institute for Field and Vegetable Crops, Novi Sad, Rimski šančevi, over a 14-year period (from 1989 to 2004, excluding 1999). Sugar beet is sown in four-year crop rotation where plant species are rotated as follows: sugar beet, corn, sunflower, and wheat. The influence of 20 variants of NKP nutritive is investigated in the trial in four replications. Each year, the same plot is given the same amount and ratio of mineral fertilizers, whereas plant species are rotated as mentioned above. Mean values of root rot and bearded root, of yield on all fertilized variants relative to control as well as the amount of precipitation relative to the vegetative period and corresponding years are presented in the paper (Table 1). The influence of NPK nutritive on the intensity of the appearance of root rot and bearded root are evaluated at the end of vegetation, during sugar beet harvesting. Ocular evaluation of 50 roots taken from each of the plots and genotypes, the intensity of the occurrence was registered.

In order to investigate the soil infestation, the occurrence and distribution of *beet necrotic yellow vein virus*, soil sampling was conducted. Samples were taken in production areas of sugar beet refineries Vrbas, Crvenka, Žabalj, Bač, Senta, Zrenjanin, Kovačica, Nova Crnja and Pećinci, meaning Bačka, Banat and Srem, three regions of Vojvodina where sugar beet is grown in our country, over the period of eight years (1997—2004). The number of hectares inspected on the presence of virus relative to years and regions is presented in Table 1. In order to determine the presence of virus and its distribution in the soil, from each 10 ha, one average soil sample was taken. Individual soil sampling was done by bin samplers at the depth of 30 cm according to the predetermined plan (chess system) at every 10 ha. Plastic dishes of the volume 1 l were filled with the collected soil samples. Then, sensitive variant, Delta was sown into these dishes. Dishes were kept in glasshouse for six weeks. After six weeks, emerged sugar beet plants were collected from the ground, the root was taken and the average sample was made in order to be tested on the presence of the virus. The presence of beet necrotic yellow vein virus was confirmed by enzyme-linked immunosorbent assay, (C l a r k and A d a m s, 1977), DAS-ELISA-test. For these tests, IgG and IgG-konjugate anti-bodies of beet necrotic yellow vein virus were used, produced by "Bioreba", Basel. Healthy beet root grown in the same way on sterile soil was used as the negative control.

RESULTS

Seedling damping-off

Seedling damping-off and crop thinning occurs every year in Vojvodina to a higher or lesser extent, depending on the number of agroecological factors.

Parasitic damping-off

In the course of many-year studies of harmful population of phitopathogenic fungi, it was determined that on the diseased seedlings seed transmitted or soil borne fungi are dominant (M a r i ć, 1963). Concerning the frequency and pathogenicity, *Phoma betae* is considered to be the most important causal agent of sugar beet seedling damping-off. The main resource of inoculum was the seed. Temperature and soil humidity are the basic pre-conditions for the occurrence of parasitic seedling damping-off. Temperatures above 20°C are extremely favorable for the development of the mentioned parasites, thus, parasitic seedling damping-off rarely occurs with early sowing. The weakening of seedlings due to droughts causes stronger fungi attacks belonging to *Fusarium* genus. Seed quality has a great influence on the occurrence of seedling damping-off. Healthy seed, characterized by good germination and germination viability are basic pre-conditions of achieving strong, vital seedlings which at the same time are resistant to parasitic damping-off. Technical processing of seed removes the pericarp layer and the greatest part of harmful micro flora with it (M a r i ć and S t o j š i n, 2004).

Non-parasitic damping-off

With the transfer to using monogerm seed and with the intensive application of chemical substances, important changes occurred in the etiology of seedling damping-off. Non-parasitic causes of this disease like crust soil, drought, frost, toxic effect of herbicides, insecticides and mineral fertilizers are met more often (M a r i ć and S t o j š i n, 2004).

Root rot

Fusarium species are dominant causal agents of sugar beet root rot in Vojvodina (65,8%). Species *Macrophomina phaseolina* (10,1%), *Alternaria* spp. (10,5%), *Rhizoctonia solani* (4,7%) and other fungi genera are registered in much lesser percentage (Figure 1).

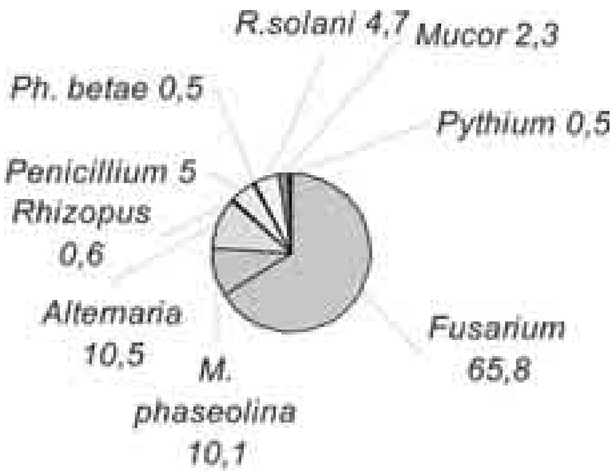

Fig. 1. Average occurence of fungus (%) in isolations in period 2000—2005. years

Fusarium root rot (Fusarium spp.*)*

General opinion is that root rots in our conditions are caused by fungi belonging to *Fusarium* genus (Marić, 1992, Stojšin, Vera, 2001, Jasnić et al., 2001, Stojšin, Vera et al., 2002, Jasnić et al., 2004, Marić, Stojšin, Vera, 2004). According to almost all the authors, the decisive factor influencing the occurrence of the disease are ecological conditions during vegetation. The disease is occurs more intensively in the years with dry summers. The weakening of plants in the conditions of high soil and air drought leads to the intensified appearance of parasites on root hair and side roots, especially on the poor soil types and in the conditions of low nutrition of plants. Leaf chlorosis and plant wilting are visible symptoms appearing in the second part of beet vegetation. Surface root tissues become gray-brownish in colour and soften and rot in humid conditions. Over the last years, rot of the root tail was noticed which deteriorates in the first part of vegetation. Concerning the healthy tissue, proliferation of side roots and bearded root often appears. *Fusarium oxysporum* is the dominant causal agent of root rot. Over the last years, as causal agents of rot the following species were also determined: *F. solani, F. equiseti, F. proliferatum, F. semitectum, F. graminearum*, but their importance is almost insignificant.

Charcoal root rot

Macrophomina phaseolina Tassi, Goidanich
(sin. *Sclerotium bataticola* Taub. Butl.)

M. phaseolina was the dominant causal agent of beet root rot and plant wilting in Vojvodina in 1992 (Stojšin, 1993). Symptoms of the disease are revealed in wilting of the diseased plants. Infested tissues are gray-brownish or black in colour with silver shine. Diseased rhizoderm gets thinner, breaks and easily divides from other parts of tissue. Within rhizoderm, numerous fungi microsclerotia are formed. Interior tissue of the infested root is of pith appearance, yellowish and eventually brown-black in colour. Highly infested root in dry conditions mummifies and in humid conditions, humid rot appears. Charcoal rot develops more intensively in the conditions of intensive drought and high temperatures during summer (M a r i ć and S t o j š i n, 2004).

Rhizoctonia *root rot*

Thanatephorus cucumeris (anamorf *Rhyzoctonia solani*)

Based on our research, it can be seen that *Rhizoctonia solani* is present on fields where sugar beet is grown. In the last years, the intensive occurrence of this parasite is registered (4,7%) (Figure 1). The first symptoms observed on diseased plants are sudden chlorosis and leaf wilting. Later, black necrosis of leaf stands appears, most frequently near the head of the root. Wilted leaves die quickly, forming brown-black rosette from the dead leaves, which remains during the whole period of vegetation. Root rot and head rot can be complete or partial. On the infested root, brown or black areas are observed. They can unify capturing most parts of the root or the whole root. Deep cracks often appear near the head of the root. In the humid conditions, softening of tissue appears as well as the symptoms of humid rot. The second type of symptoms on the root is dry rot manifested with concentric, dark or light-brown areas. Below the lesions, mycelium of the parasite is formed with distinctive margins between healthy and infested tissue.

The influence of mineral nutrition on sugar beet root rot and bearded root

Sugar beet root rot and bearded root occurred almost regularly, in conditions of different mineral nutrition of plants as well as in the control variant. The most frequent appearance of these diseases was registered in very dry years as 2000 was when root rot in fertilized variants was 89% and in the control 96% and bearded root 41,6% and 22%, which affected root yield (fertilized treatments 44t/ha and control only 25t/ha) (Table 1). These diseases did not occur in very favorable conditions for sugar beet growth (2004), when the best yields were achieved. Root rot appeared more intensively in control variant of the trial and bearded root was more prominent on fertilized crops. In this trial, drought was the most important factor of the appearance of the diseases and low sugar beet root yield.

Table 1. Intensity of root and root bearding in condition of different mineral nutrition during 14 year invastigation

Year		89	90	91	92	93	94	96	97	98	00	01	02	03	04	Average
Root rot %	fertislised	0.0	5.8	3.3	19.1	1.4	2.1	4.3	0.9	2.1	89.0	0.0	0.7	0.0	0.0	9,2
	non fertilised	0.0	3.0	18.0	26.0	0.0	2.0	10.8	1.0	1.0	96.0	0.5	1.2	3.5	0.0	11,6
Bearded roots %	fertislised	1.2	1.3	4.7	1.2	3.4	2.3	17.1	7.3	4.0	22.0	3.6	2.0	1.1	0.0	5,0
	non fertilised	0.0	1.3	4.7	1.2	3.4	2.3	17.1	7.3	4.0	22.0	3.6	2.0	1.1	0.0	5,0
Root yield t/ha	fertilised	49.5	29.3	—	25	38	34	51	54	47	44	60	59	45	82	47,5
	non fertilised	38.1	23.9	—	21	29	22	38	39	34	25	40	40	27	70	34,4
Precipitation IV—IX month (mm)		354	217	487	229	249	345	250	433	491	148	742	279	237	459	—
Annual precipitation (mm)		507	451	779	532	498	569	814	764	755	288	999	482	501	836	—

*Sugar beet Rhizomania (*Beet necrotic yellow vein virus*)*

Results concerning distribution of beet necrotic yellow vein virus in Vojvodina in the period of 1997—2004 are shown in table 2. Over eight years of investigating the infestation of soil, total area of 67.213 ha was inspected, out of which 24.674 ha was infested with *Rhizomania*, i.e. 36,7% of the area, on average, more than one third.

Table 2. Distribution of beet necrotic yellow vein virus relative to regions of sugar beet growing in Vojvodina over the period of 1997—2004.

Years	Srem			Banat			Bačka			Sum of inspected fields (ha)	Infected (ha)	
	Sum of inspected fields (ha)	Sum of infected		Sum of inspected fields (ha)	Sum of infected		Sum of inspected fields (ha)	Sum of infected			No. of hectares	% ha
		No. of hectares	%		No. of hectares	%		No. of hectares	%			
1997	427	295	69,1	2110	912	43,2	2580	150	5,8	5177	1357	26,2
1998	348	100	28,9	6376	2397	37,5	6975	1293	18,5	13699	3790	27,6
1999	—	—	—	2365	1013	43,0	3262	710	21,8	5627	1723	30,6
2000	—	—	—	2006	751	37,4	4452	2522	56,6	6458	3273	50,7
2001	—	—	—	2176	1951	89,6	5139	2603	50,6	7315	4554	70,0
2002	320	50	15,6	3060	1440	47,1	15874	4773	30,1	19254	6263	32,5
2003	—	—	—	701	223	31,8	4555	1956	42,9	5256	2179	41,4
2004	—	—	—	—	—	—	4427	1535	34,7	4427	1535	34,7
Sum	1095	445		18795	8687		47264	15542		67213	24674	
Average			40,6			46,2			32,9			36,7

From table 2, the tendency of virus spreading and the increase in infested areas in Vojvodina can also be seen. However, distribution of the virus in Vojvodina varies depending on the year.

DISCUSSION

During our investigations of causal agents of sugar beet root rot by isolating from rotten roots, *F. oxysporum* species was most commonly gained, besides *F. solani* and *R. solani* and *M. Phaseolina* fungi. Dominant distribution of *F. oxysporum* species as the causal agent of root rot is also emphasized by other authors (Snyder, Hansen, 1940, Marić, 1974, Whitney, Diffus, 1986, Ruppel, 1991, Jasnić et al., 2001, Marić, Stojšin, Vera, 2004). Distribution of other fungi like *R. solani* (4,7%) and *M. phaseolina* (2,8%) was much lower and depended on weather conditions. According to many authors, weather conditions during the period of vegetation are decisive factors influencing the distribution of certain fungi species, causal agents of root rot (Marić, 1974, Balaž, Stojšin, Vera, 1997, Jasnić et al., 2001, Jasnić et al., 2004).

Rhizoctonia solani, causal agent of charcoal root rot appears in years with warm and humid summers. These conditions favorably influence the development of this fungus (Parmeter, 1970). These conditions are rarely seen in our areas, thus, that is one of the reasons of lower incidence of *R. solani.*

By analyzing the soil samples over the period of 1997—2004, in order to determine the areas infested by Rhizomania, significant distribution of beet necrotic yellow vein virus was observed in Vojvodina (Table 2). Beside precise data about the spreading and distribution of virus in many European countries (Blunt, 1989), no data were available about the distribution of Rhizomania in Serbia (Ivanović, 1996). It is well-known that beet necrotic yellow vein virus, causal agent of Rhizomania is widespread in our country. Since it was discovered in Srem in 1977 (Šutić and Milovanović, 1978), virus has spread on significant areas in many regions where sugar beet is grown in Srem, Banat, Bačka (Šutić et al., 1986, Jasnić et al., 1999 a, Jasnić et al., 1999 b) with the tendency of spreading in other parts of Serbia as well.

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БОЛЕСТИ КОРЕНА ШЕЋЕРНЕ РЕПЕ У ВОЈВОДИНИ

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Резиме

У раду се дају преглед болести корена шећерне репе током вишегодишњег периода у Војводини и резултати испитивања њихове етиологије. Интензитет појаве ових болести зависио је од временских услова током вегетације и од примењених агротехничких мера. Палеж клијанаца, фузариозна и угљенаста трулеж, паразитна (ризоманија) и непаразитна брадатост корена биле су најучесталије болести корена. Већина паразитних болести клијанаца се интензивније јављала у периоду примене екстензивне агротехнике. *Fusarium oxysporum* је најчешћи проузроковач фузариозне трулежи репа корена. Последњих година детерминисане су и следеће врсте: *F. solani*, *F. equiseti*, *F. proliferatum*, *F. semitectum* и *F. graminearum*, али њихов значај је много мањи. Угљенаста трулеж корена и увенуће биљака (*Macrophomina phaseolina*) изазивају велике штете на шећерној репи, нарочито у условима јаке суше и високих температура током лета. Ризоманија шећерне репе (BNYVV) је широко распрострањена у Војводини, пошто је вирус у периоду 1997—2004. утврђен на 36,7% (24674 ha) површина од укупно 67.213 ha прегледаних. Последњих неколико година регистрована је интензивнија појава *Rhizoctonia solani* проузроковача мрке трулежи корена на појединим подручјима Војводине.

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EVALUATION OF QUALITY OF SUGAR BEET GROWN ON SOILS HIGHLY INFECTED WITH *RHIZOMANIA**

ABSTRACT: A field trial study with sugar beet varieties having different resistances to *Rhizomania* was conducted at two test sites in 2004. The field trials were located at Ruma (the Agricultural station) and at Sremska Mitrovica (the Institute of Agriculture). At both locations, twenty-one sugar beet varieties and a control variety (intolerant to the disease) were planted. The selected varieties were provided from several seed companies distributing seed material in Serbia.

At Ruma, the difference between the first-ranked variety Alvira (100.82 t/ha) and the control variety (61.63 t/ha) was 39.19 t/ha or 38.87%. But, significant variability in processing quality within varieties and the control variety was observed. For example, the difference between root sugar contents of the first-ranked variety and the control one amounted to 4.64% absolute.

At Sremska Mitrovica, significant variability of the observed parameters within varieties was also found. The highest sugar yielding variety was Leila (15.66%) producing better results for 3.42% absolute in comparison to the control variety. This variety produced good stands for the other parameters, too.

KEY WORDS: processing quality, *Rhizomania*, root yield, sugar beet, sugar content, sugar yield

INTRODUCTION

The role of variety on yield and quality attributes in the production of all agricultural crops is very important. It is a known fact that cultivar yield depends on two groups of factors: a) variety and b) processing technology (K o -

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v a č e v, 1992). In Europe, many researchers have been involved in studies on quality performances (B u r b a and H a r l i n g, 2003) of sugar beet as well as in quality management in sugar beet cultivation (B u r b a and J a n s e n, 2000). The achieved root yields and sugar percentages have been significantly higher than those reported thirty years ago. But, during the last decade, drastic decline of yields and processing quality of sugar beet has been observed in Serbia due to many reasons: reduced economic ability of produceres, obsolete mechanization, inadequate cultivation techniques, occurence of soil-borne disease — *Rhizomania*, etc. According to T o š i ć (1995), several tens of thousands of hectares have been affected by the disease in Serbia.

MATERIAL AND METHODS

Registered foreign and domestic varieties of sugar beet tolerant to rhizomania were studied in a trial conducted at two localities (Ruma and Sremska Mitrovica experiment stations). The study also included some varieties and hybrids considered for registration at the Federal Committee for Varieties. Sugar beet seed material was obtained from local sugar factories under the supervision of the Committee members. The samples were coded. During the first decade of november, after harvest, experimental work and data processing were done, the samples decoded.

The experimental material comprised twenty-one varieties: Chiara, Leila, Rama and Bjanka, selected from the collection of KWS, Germany, then Merak, Libero, Esprit, Remos, Stru 2206 and Donna from the collection of Strube-Dieckmann, Germany, then Sofarizo, Dorotea and HI 0135 from the collection of Hilleschog, Sweden, then Lion 06 YU and Ivona from the collection of Lion Seeds, England, then Opera, Porto and Concerto representing the collection of Delitzsch, Germany and Aleksina-R and Alvira from the collection of Aleksinac, Serbia.

A foreign, *Rhizomania* intolerant variety was also planted as a control sample. Variety Rama was the standard reference.

The cultivars were planted in a randomized complete block experimental design with five replicates at each location. The size of experimental plots was 19,60 cm^2. Quality tests were determined according to the standard methods used in sugar industry in Serbia.

Two-way analysis of variance (ANOVA) was used for the analysis of data on the most important quality parameters of sugar beet.

RESULTS

Results of micro-trials at Ruma

The achieved root and sugar yields as well as other parameters of quality performance, significantly varied depending on variety. The average root yield for this micro-trial was high and amounted up to 87,59 t/ha. But, the results showed significant variability in root yield among varieties. For example, Alvira had the highest root yield (100.82 t/ha) and the lowest root yield (61,63 t/ha) was recorded for the control sample (intolerant to *Rhizomania*). Thus, the extreme difference in root yield between two cultivars was 39.19 t/ha or 38.87%. Significant differences in root yield were observed within other examined varieties, too (Table 1).

Table 1: Results of sugar beet field trial at Ruma in 2004.

No.	Variety		Root yield (t/ha)	Sugar content (%)	Sugar utilization (% on beet)	Crystalline sugar yield (t/ha)
1	Dorotea		86,02	13,83	10,97	9,423
2	Chiara		98,67	13,65	10,94	10,778
3	Lion 06 YU		94,26	13,50	11,06	10,422
4	Donna		97,04	14,29	12,05	11,692
5	Sofarizo		82,45	14,10	11,55	9,533
6	Aleksinac-R		84,90	13,28	10,32	8,753
7	Opera		84,59	13,75	11,16	9,428
8	Porto		92,45	14,20	11,65	10,694
9	Esprit		77,96	13,75	11,38	8,879
10	Remos		88,27	14,31	12,16	10,734
11	Concerto		97,45	13,30	10,46	10,202
12	Alvira		100,82	12,79	10,13	10,214
13	Libero		88,57	13,95	11,57	10,259
14	Leila		79,59	15,00	12,60	10,025
15	Merak		83,67	14,10	11,62	9,712
16	Ivona		88,06	14,61	12,26	10,796
17	Rama		81,33	14,25	11,60	9,419
18	Hi 0135		91,63	14,44	11,83	10,832
19	Strube 2206		92,24	14,46	12,13	11,184
20	Bjanka		87,86	13,99	11,51	10,123
21	Control		61,63	10,36	7,58	4,672
Average			87,59	13,80	11,26	9,894
LSD	Variety	0,05	10,02	0,50	0,55	1,191
		0,01	13,28	0,66	0,73	1,579
Cv		(%)	12,74	7,18	10,01	16,32

The variation in sugar content was significant among the varieties at this locality. The average sugar content for this trial was 13.80% and it was a medium one considering the agroecological conditions in the year (Table 1).

The extreme difference in sugar yield between the first-ranked variety (Leila, 15.00%) and the last-ranked one (control, 10.36%) amounted up to 4.64% absolute or 30.93% relative. Statistically significant differences for sugar content were calculated for all other varieties (Table 1).

Even greater variability among cultivars was recorded for other quality parameters. For example, sugar utilization (% calculated on beet), between the first-ranked Leila (12.60%) and control (7.58%) amounted up to 5.02% absolute or 39.84% relative (Table 1).

Extreme differences for other quality parameters were as follows:

— coefficient of thick juice, 4.10,
— sugar content in molasses, 0.81% calculated on beet,
— potassium content, 9.21 mmol/100°S,
— sodium content, 26.32 mmol/100°S,
— alpha-amino nitrogen content varied depending on the tolerance of cultivar to *Rhizomania* (Table 1a).

Table 1a: Results of sugar beet field trial at Ruma in 2004.

No.	Variety		Q saturated juice	Sugar in molasses, % on beet	K	Na	α-amino N
					mmol/100°S		
1	Dorotea		89,50	2,26	24,61	23,87	20,61
2	Chiara		90,22	2,11	23,76	23,41	16,88
3	Lion 06 YU		90,85	1,84	20,59	21,01	18,06
4	Donna		92,06	1,64	18,88	16,63	15,63
5	Sofarizo		90,83	1,95	20,64	21,10	18,05
6	Aleksinac-R		88,09	2,36	27,54	23,42	28,01
7	Opera		90,75	1,99	19,27	25,22	15,84
8	Porto		90,84	1,95	19,80	22,03	17,85
9	Esprit		91,22	1,77	19,71	19,56	17,75
10	Remos		92,19	1,55	20,43	12,84	17,00
11	Concerto		89,49	2,24	23,61	27,20	18,38
12	Alvira		89,84	2,06	21,35	27,97	17,37
13	Libero		91,32	1,78	20,52	18,30	17,53
14	Leila		91,85	1,80	19,78	17,01	15,80
15	Merak		90,07	1,88	20,07	20,11	18,65
16	Ivona		91,58	1,75	21,33	14,70	18,52
17	Rama		90,20	2,05	25,62	16,82	21,78
18	Hi 0135		90,50	2,01	19,24	21,86	20,98
19	Strube 2206		91,62	1,73	21,35	14,90	18,00
20	Bjanka		90,89	1,88	23,88	16,73	18,72
21	Control		88,13	2,18	28,09	39,16	11,42
Average			90,62	1,94	21,91	21,14	18,23
LSD	Variety	0,05	0,77	0,16	1,53	3,15	2,68
		0,01	1,02	0,2	2,03	4,17	3,56
Cv		(%)	1,43	12,68	13,54	29,23	21,52

The most important quality attribute, crystalline sugar yield also varied across wide ranges for the investigated varieties. The first-ranked variety Donna (11.692 t/ha) performed higher crystalline sugar content by 7.020 t/ha or 60.04% relative in comparison to the control (4.672 t/ha).

Results of micro-trials at Sremska Mitrovica

The average root yield at this site was 78.64 t/ha. The variation in this parameter was statistically significant within the varieties. The most marked difference was recorded between the first-ranked variety (Chiara, 87.47 t/ha) and the control (53.68 t/ha) and it amounted up to 33.79 t/ha or 38.63% (Table 2).

Table 2: Results of sugar beet field trial at Sremska Mitrovica in 2004.

No.	Variety		Root yield (t/ha)	Sugar content (%)	Sugar utilization (% on beet)	Crystalline sugar yield (t/ha)
1	Dorotea		76,52	14,40	11,42	8,732
2	Chiara		87,47	14,10	10,76	9,412
3	Lion 06 YU		84,62	15,00	11,90	10,070
4	Donna		82,03	15,28	12,35	10,133
5	Sofarizo		80,66	14,89	11,82	9,525
6	Aleksinac-R		80,43	14,53	11,20	9.006
7	Opera		73,71	15,34	12,33	9,084
8	Porto		80,80	14,80	11,80	9,534
9	Esprit		76,46	15,08	12,23	9,349
10	Remos		79,11	15,33	12,74	10,077
11	Concerto		86,73	14,33	11,01	9,548
12	Alvira		80,70	14,71	11,59	9,350
13	Libero		82,34	15,14	12,33	10,148
14	Leila		79,86	15,66	12,96	10,352
15	Merak		82,33	15,48	12,75	10,498
16	Ivona		67,37	15,45	12,74	8,588
17	Rama		75,04	15,31	12,33	9,253
18	Hi 0135		77,92	15,55	12,64	9,851
19	Strube 2206		82,01	15,57	12,81	10,507
20	Bjanka		81,74	15,14	12,14	9,921
21	Control		53,68	12,24	8,82	4,735
Average			78,64	14,92	11,94	9,413
LSD	Variety	0,05	1,92	0,46	0,59	0,493
		0,01	2,56	0,60	0,78	0,654
Cv		(%)	9,22	5,52	8,65	10,12

The results have shown a significant effect of variety on the most important quality parameters of sugar beet with the most marked differences listed below:

— sugar content, 3.42% apsolute or 21.84% relative,
— sugar utilization, 4.14% calculated on beet or 31.94% relative (Table 2),
— coefficient of thick juice, 3.97,
— sugar content in molasses, 0.83% calculated on beet,
— potassium content, 11.25 mmol/100°S,
— sodium content, 23.62% mmol/100°S and alpha-amino nitrogen content, too (Table 2a).

Table 2a: Results of sugar beet field trial at Sremska Mitrovica in 2004.

No.	Variety		Q saturated juice	Sugar in molasses, % on beet	K	Na	α-amino N
					mmol/100°S		
1	Dorotea		89,20	2,38	26,39	22,07	22,73
2	Chiara		87,56	2,74	30,48	25,23	26,99
3	Lion 06 YU		88,81	2,50	26,45	20,90	26,59
4	Donna		89,49	2,33	25,80	17,58	25,79
5	Sofarizo		88,73	2,47	24,95	22,02	27,55
6	Aleksinac-R		87,25	2,73	31,45	20,58	32,85
7	Opera		89,49	2,41	23,32	21,86	23,98
8	Porto		88,84	2,40	25,76	20,07	27,90
9	Esprit		89,56	2,25	24,54	17,64	26,53
10	Remos		90,42	1,99	23,73	12,79	26,15
11	Concerto		87,54	2,72	28,80	24,76	29,30
12	Alvira		88,58	2,53	25.53	23,31	26,73
13	Libero		89,80	2,21	23,18	18,38	25,45
14	Leila		90,56	2,10	22,20	16,31	23,17
15	Merak		90,27	2,13	23,40	15,83	24,45
16	Ivona		90,39	2,11	24,76	14,41	23,65
17	Rama		89,27	2,38	28,68	15,23	26,79
18	Hi 0135		89,42	2,31	23,22	18,22	28,22
19	Strube 2206		89,88	2,16	24,95	13,80	27,66
20	Bjanka		89,08	2,40	27,59	17,26	27,17
21	Control		86,59	2,82	33,45	36,41	19,64
Average			89,08	2,38	26,13	19,75	26,16
LSD	Variety	0,05	0,98	0,19	2,30	3,19	3,41
		0,01	1,30	0,26	3,06	4,23	4,52
Cv		(%)	1,47	11,74	13,21	28,51	13,90

The most marked difference in crystalline sugar content was recorded between Strube 2206 (10.507 t/ha) and the control (4.735 t/ha) and amounted up to 5.772 t/ha or 54.93% (Table 2).

DISCUSSION

The beet root yields achieved at both localities in 2004 were high and if averaged across varieties and sites the mean root yield amounted to 83.12 t/ha. But, the average root yield of the control sample (intolerant to *Rhizomania*) was 57.66% at both sites. Thus, root yield of the control variety has decreased by 25.46 t/ha or 30.63% relative. Similar results were reported by Radivojević et al. (2001).

The variability in beet sugar content averaged across varieties and sites and between mean values at both sites and mean value of the control amounted up to 3.06% or 21.31% relative. Marlender and Rover (1994) also reported significant effect of variety on sugar content (8.72% relative), but lower still comparing to the results of this experiment.

The values of the other quality parameters (sugar utilization, coefficient of saturated diffusion juice, sugar content in molasses, potassium and sodium content, alpha-amino nitrogen content) were significantly lower in comparison to the means at both sites. For example, sugar utilization for the first-ranked variety Leila, averaged across sites was 83.5% and for the control 72.5%. The obtained difference was 11.0% which is a very high value. This result is in accordance with the findings of Richard-Molard and Carialle (2001) proving that the selection of varieties tolerant to *Rhizomania* enables high yields and good processing quality of sugar beet.

Comparing the yields of crystalline sugar averaged across sites between the first-ranked (11.100 t/ha) and the control variety (4.703 t/ha), very high difference can be observed, 6.397 t/ha or 57.63%. But, higher yields of crystalline sugar could be achieved by increasing the yields of beet root as well (Marlender, 1991).

CONCLUSION

The results of the study revealed significant variations in root and sugar yield within varieties having different tolerances to *Rhizomania*.

The established difference in root yield, averaged across sites, between the first-ranked (94.15 t/ha) and the control (57.66 t/ha) variety was 36.49 t/ha or 38.76%.

The most marked difference in location averages of sugar content between the first-ranked variety Leila (15.33%) and the control (11.30%) was 4.03% or 26.29% relative.

Very high difference in crystalline sugar content, averaged across sites was eshtablished between the first-ranked and the control variety and amounted up to 6.397 t/ha or 57.63%.

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ОЦЕНА ТЕХНОЛОШКОГ КВАЛИТЕТА ШЕЋЕРНЕ РЕПЕ УЗГАЈАНЕ НА ЗЕМЉИШТУ СА ВИСОКИМ СТЕПЕНОМ ПРИСУСТВА РИЗОМАНИЈЕ

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Резиме

На локалитетима у Руми и Сремској Митровици, у току 2004. године, изведени су сортни микроогледи шећерне репе, са сортама различите толерантности на ризоманију. Микроогледи шећерне репе били су засејани у Пољопривредној станици у Руми и у Пољопривредном институту у Сремској Митровици. На оба микроогледа биле су засејане исте сорте, различите толерантности на ризоманију, са укупно двадесет и једном сортом, укључујући и контролу. Засејане сорте шећерне репе припадале су различитим селекционим кућама, које су заступљене у структури сетве у нашој земљи.

Установљена разлика у приносу корена на микроогледу у Руми између прве по рангу (Alvira, 100,82 t/ha) и контроле (61,63 t/ha) износила је 39,19 t/ha или 38,87%. Међутим, у погледу технолошког квалитета шећерне репе разлике су биле веома изражене, у односу на контролу (нетолерантну на ризоманију). Примера ради, утврђена разлика у садржају шећера у репи између прворангиране и контроле износила је 4,64% апсолутних.

На локалитету у Сремској Митровици такође је утврђена значајна разлика између испитиваних сорти, како у приносу корена и шећера, тако и у технолошком квалитету. Прворангирана сорта у садржају шећера у репи (Leila, 15,66%) била је боља у односу на контролу за 3,42% апсолутних, а такође и у односу на друге показатеље квалитета.

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INCIDENCE AND DISTRIBUTION OF *BEET NECROTIC YELLOW VEIN VIRUS* IN VOJVODINA*

ABSTRACT: From 1997 to 2004, 67213 ha were surveyed in Vojvodina in order to determine the incidence and distribution of *beet necrotic yellow vein virus* (BNYVV), the causer of *Rhizomania* on sugar beet in the fields in Vojvodina. The number of inspected hectares was different and ranged from 4.427 ha in 2004 to 19.254 ha in 2002.

The survey showed that BNYVV is not equally widespread in all sugar beet growing areas of Vojvodina. The regions of Srem and Banat had higher incidence of the virus, while in region of Bačka the incidence of virus was lower than in other parts of Vojvodina. The BNYVV was found, on average, on 46,2% in Banat, on 40,6% in Srem and on 32,9% in Bačka of sugar beet acreages involved, during the period of eight years (1997—2004).

These results show that BNYVV is widespread in Vojvodina, since the virus was found on 36,7% (24.674 ha) of acreages from 67.213 ha of total sugar beet acreages inspected on incidence of BNYVV in the period from 1997 to 2004.

KEY WORDS: beet necrotic yellow vein virus, ditribution, sugar beet, Vojvodina

INTRODUCTION

Rhizomania, caused by *beet necrotic yellow vein virus* (BNYVV) is one of the most important sugar beet diseases in our region and in the world. The disease symptoms are leaf chlorosis, leafpetal elongation, leaflet narrowing, root dwarfing, dividing and bearding. On the cross section, the vascular tissue necrosis can also be observed. Leaf and leafveins necrosis are very rare symptoms (Tošić et al., 1978, Tošić, 1982).

Rhizomania causes great losses, decreasing root yield (for about 50%) and digestion (between 3 and 4% or more) (Šutić and Milovanović,

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1978, M i l o v a n o v i ć, 1989). *Rhizomania* was described for the first time in Italy (C a n o v a, 1959). Today, the disease is widely distributed in almost all European countries, Asia and North America (B l u n t, 1989). In our contry, this virosis was found in 1977 (Š u t i ć and M i l o v a n o v i ć, 1978). Although the significant appearance of *Rhizomania* and yield losses in Vojvodina were described, we had no accurate information about virus distribution in Vojvodina.

The goal of these investigations was to determine the soil infestation with *beet necrotic yellow vein virus* and on the basis of the information obtained to determine the distribution of virus in the province of Vojvodina.

MATERIAL AND METHODS

For the analysis of soil infestation and virus distribution asessment, soil sampling was conducted during eight years (1997—2004) in beet production regions of sugar rafineries Vrbas, Crvenka, Žabalj, Bač, Senta, Zrenjanin, Kovačica, Nova Crnja and Pećinci, more precisely from all three regions of Vojvodina: Bačka, Banat and Srem.

The total number of inspected fields during eight years of investigations as well as regions are presented in Table 1.

Tab. 1 Distribution of sugar beet *Rhizomania* in Vojvodina during 8 year of investigations (1997—2004).

Years	Regions of Vojvodina									Sum of inspected fields (ha)	Total infected area (ha)	
	Srem			Banat			Bačka					
	Sum of inspected fields (ha)	Sum of infected area		Sum of inspected fields (ha)	Sum of infected area		Sum of inspected fields (ha)	Sum of infected area			No. of hectars	% ha
		No. of hectars	%		No. of hectars	%		No. of hectars	%			
1997	427	295	69,1	2110	912	43,2	2580	150	5,8	5177	1357	26,2
1998	348	100	28,9	6376	2397	37,5	6975	1293	18,5	13699	3790	27,6
1999	—	—	—	2365	1013	43,0	3262	710	21,8	5627	1723	30,6
2000	—	—	—	2006	751	37,4	4452	2522	56,6	6458	3273	50,7
2001	—	—	—	2176	1951	89,6	5139	2603	50,6	7315	4554	70,0
2002	320	50	15,6	3060	1440	47,1	15874	4773	30,1	19254	6263	32,5
2003	—	—	—	701	223	31,8	4555	1956	42,9	5256	2179	41,4
2004	—	—	—	—	—	—	4427	1535	34,7	4427	1535	34,7
Sum	1095	445		18795	8687		47264	15542		67213	24674	
Average			40,6			46,2			32,9			36,7

For virus analysis, from every 10 hectars of field, one average sample was formed. The average sample was obtained from 20 individual, smaller samples, which were then combined. The individual samples were collected by soil sonde from 30 cm depth according to chess-table pattern on every 10 ha of investigated surface.

The plastic containers, volume 1l were filled with the collected soil samples. The seeds of succeptible sugar beet genotypes, Delta were sown in those pots. The plants were grown during 6 weeks in greenhouses of Department of sugar beet, Scientific Institute of field and vegetable crops. After that period, the plants were removed from soil, their roots were collected and the average root sample was formed for virus presence analysis (F r a n c et al., 1996). The BNYVV determination was made by DAS-ELISA-test (C l a r k and A d a m s, 1977). For serological analysis, Bioreba (Basel) commercial IgG antiserum and IgG conjugate were used. Roots of healthy beet plants, grown in sterile soil were used as negative control.

RESULTS

Distribution of *beet necrotic yellow vein virus* in Vojvodina, during 1997—2004 are presented in table 1. During eight year of investigation of BNYVV distribution, the total area examined was 67.213 ha. More then 1/3 of investigated surface proved to be infected with virus: precisely, 24.674 ha of fields area were infected, which is 36,7% of total area investigated.

On the basis of obtained information during period of eight year, it can be concluded that the most intense distribution was registered in Banat, with average of 46,2% of infected field, but smaller infection intensity was registered in Bačka (average 32,9%). From data in table 1. it can also be seen that the incidence and distribution of virus depends on the year, examined area, as well as on suitable climatic conditions for virus spreading during the investigated year. Meanwhile, there is clear tendency of increase in infected areas and the spread of virus distribution in Vojvodina in the period of 1997—2004. This tendency is particulary present in Bačka region, where during the first year of investigation infection level of 5,8% was detected, but during the next few investigated years, a sudden increase in infected surfaces was detected.

DISCUSSION

On the basis of soil samples analysis during 1997—2004 in Vojvodina, conducted to determine the presence of *beet necrotic yellow vein virus*, significant virus distrubution was established (Table 1). Apart from clear evidence about spreading and distribution of virus in many European countries (B l u n t, 1989), there were no data about *Rhizomania* distribution in Serbia (I v a n o v i ć, 1996). It is known that the BNYVV is present in our country. After the first evidence of this virus in Srem in 1977 (Š u t i ć and M i l o v a n o v i ć, 1978), virus spread and expanded to significant areas in many beet production areas in Srem, Banat, Bačka and Pomoravlje (I v a n o v i ć, D., 1979; T o š i ć et al., 1985, Š u t i ć et al., 1986, J a s n i ć et al., 1999 a, J a s n i ć et al., 1999 b), with further tendency of spreading to other parts of Serbia. In that context, *Rhizomania* was noted for the first time in 1989 in Mačva region (B. Krstić and Tošić, 1990).

According to results in this paper, which is the first effort made to form sistematic registration and evidence of BNYVV distribution, it can be concluded that the virus is significantly distributed in Vojvodina. Beet growing fields in Srem and Banat are highly infected and in Bačka the tendency of virus spreading to non-infected fields is also registered, although the infection level is still not high.

One important protection measure is growing tolerant beet cultivars or hybrids on infected fields. With the introduction of new, virus tolerant genotypes into production, the losses caused by *Rhizomania* are brought down to acceptably low level (Kovačev et al., 2004).

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ПОЈАВА И РАСПРОСТРАЊЕНОСТ ВИРУСА НЕКРОТИЧНОГ ЖУТИЛА НЕРАВА ШЕЋЕРНЕ РЕПЕ*

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Резиме

У периоду од 1997. до 2004. године на територији Војводине прегледано је укупно 67.213 ha усева шећерне репе у циљу одређивања појаве и распрострањености вируса некротичног жутила нерава шећерне репе (ВНЖНР), проузроковача ризоманије. Број прегледаних хектара је варирао од 4.427 ha у 2004. до 19.254 ha у 2002. години.

Резултати истраживања су показали да вирус некротичног жутила нерава шећерне репе није равномерно распрострањен у свим рејонима гајења шећерне репе у Војводини. Појава обољења је интензивнија на подручју Срема и Баната, док је у Бачкој појава овог вирусног обољења нижа. У осмогодишњем периоду ВНЖНР је у просеку у Банату утврђен на 46,2%, у Срему на 40,6%, а у Бачкој на 32,9% површина под шећерном репом.

Ови резултати доказују да је ВНЖНР широко распрострањен у Војводини, пошто је вирус у периоду 1997—2004. утврђен на 36,7% (24674 ha) површина од укупно 67.213 ha прегледаних.

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VARIATION IN THE YIELD OF ROOT, SUGAR AND THE QUALITY OF SUGAR BEET DEPENDING ON VARIETY AND SOIL INFESTATION WITH RHIZOMANIA*

ABSTRACT: Sugar beet field trials were planted in 2004 in order to determine sugar and root yield and the quality of sugar beet varieties depending on varietal tolerance to *Rhizomania*. The field trials were located at the agricultural station in Kikinda, covering a highly infested area and at the "Agroinstitut" in Sombor, where no infestation had been reported. At both locations, twenty-one sugar beet varieties were planted. The selected varieties were provided from breeders distributing new selections in Serbia.

At Kikinda, beet root yield was 85.78 t/ha for Concerto variety and 12.00 t/ha for control variety (intolerant to disease). The obtained difference amounts to 73.78 t/ha or 86.01%. Difference in sugar content within the first-ranked variety Ivona (15.36%) and the control sample (10.91%) was 4.45% absolute. But, the established difference for crystalline sugar yield between the first-ranked variety Remos (9.205 t/ha) and the control variety (0.842 t/ha) amounted to 8.363 t/ha or 90.85%.

At the other location, Sombor, extreme differences within varieties were also observed but to a lesser extent.

KEY WORDS: processing quality, *Rhizomania*, sugar beet, variety, yield (% on beet)

INTRODUCTION

The quantity of sugar beet root and sugar yield mostly depends on variety, climatic and agrotechnical conditions (Kovačev et al., 2005). Lately, significant variation in sugar beet root yield and the percentage of sugar was

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observed in our environmental conditions. It is possible to moderate the observed variations in yields selecting an appropriate variety, recognizing the soil requirements, applying optimal cultivation techniques, etc.

MATERIAL AND METHODS

In 2004, field trials with sugar beet cultivars tolerant to *Rhizomania*, used in mass production were planted at two locations, Kikinda and Sombor. The trial at Kikinda was organised by the Agricultural Station on experimental field "Kinđa". The trial at Sombor was carried out on experimental fields of the Institute of Agriculture.

The scope of the study were 21 sugar beet cultivars:

— Chiara, Leila, Rama (standard reference variety) and Bjanka, selected from the collection of KWS, Germany,

— Merak, Libero, Esprit, Remos, Stru 2206 and Donna from the collection of Strube-Dieckmann, Germany, provided by distributor "Atel", Novi Sad, Serbia,

— Sofarizo, Dorotea and HI 0135 from the collection of Hilleschog, Sweden, provided by distributor "Agrostar", Novi Sad, Serbia,

— Lion 05 YU and Ivona from the collection of Lion Seeds, England, provided by distributor "Lion Seeds NS" DOO, Novi Sad, Serbia,

— Opera, Porto and Concerto representing the collection of Delitzsch, Germany, provided by distributor "Jugošećer", Belgrade, Serbia,

— Aleksina-R and Alvira from the collection of Aleksinac, Serbia.

As a control sample, one variety intolerant to *Rhizomania*, selected from the collection of foreign seed company was also planted. Variety Rama was a standard reference variety.

The cultivars were planted in a randomised complete block experimental design with five replicates at each location. The size of experimental plots was 19,60 cm^2. Quality tests were determined according to standard methods used in sugar industry in Serbia.

Sugar beet plants were lifted from the ground in optimal period (at the beginning of October). Two-way analysis of variance (ANOVA) was used for the analysis of data. Significance in the variability of means was calculated for the following parameters: root yield, sugar yield, sugar utilization (% on beet), coefficient of thick juice, sugar content in molasses (% on beet), potassium, sodium, and alpha-amino nitrogen content as well as yield of polarized and crystalline sugar.

It is also important to mention that all the samples of sugar beet cultivars and hybrids were coded. Decoding of the samples was carried out at the end of August 2004.

Environmental conditions

In April 2004, average monthly temperatures increased by 0,7°C comparing to the several-year average (11,4°C) (Table 1).

In May, monthly temperatures were 1,3°C lower than the several-year average (16,5°C). During the rest of the vegetation period, average monthly temperatures did not significantly vary from the several-year means except for October, being 1,8°C higher. Average temperature over the vegetation period increased by 0,3°C comparing to the several-year average.

Over the 2004 growing season (Nov. 2004—Oct. 2004) average rainfall (Table 2) was higher than the several-year average and was well timed. In 2004, timely and abundant rainfalls prevailed in Sombor (82,0 mm in each month or 571,0 mm total). Thus, the most important climatic factors acted favourably towards sugar beet, resulting in higher yields of root and sugar as well as good over-all quality of sugar beet during 2004.

RESULTS

a) *Rhizomania-infested soil*

The average root yield at Kikinda locality (Table 3) was 72.46 tha^{-1} and was followed by Chiara 81,49 tha^{-1}, Libero 81,24 tha^{-1}, Sofarizo 80,27 tha^{-1}, Donna tha^{-1} and others, while the control variety (susceptible to *Rhizomania*) performed rather low root yield (12,00 tha^{-1}). Variety Concerto (85,78 tha^{-1}) achieved higher root yield by 86,0% or 7,15 times higher than the control (12,00 tha^{-1}). The results showed the obvious occurrence of *Rhizomania* and the possibility for other diseases occurrence in this trial.

The percentage of sugar ranged from 15,36% for Ivona to 10,93% for the control. The difference in the percentage of sugar between the first-ranked and the last-ranked variety was 4,45% absolute or 29,0% relative. The difference was found to be statistically significant.

The variation of other quality parameters within the varieties was even more marked. For example, the most marked difference in sugar utilization in % per beet was 5,21% absolute or 42,67% relative between Stru 2206 (12,21%) and the control (7,00%).

Hybrid Stru 2206 (11,55 mmol/100°C) had 3,52 times lower sodium content than the control (40,71 mmol/100°C).

Variety Remos was among the highest in crystalline sugar yield (9,205 tha^{-1}) and the control was the lowest (0,842 tha^{-1}). The difference between these varieties in crystalline sugar content was 90,85% or 10,93 times.

b) *Soil not infested with Rhizomania*

The average sugar beet root yield at Sombor site (Table 4) was very high: 114,40 tha^{-1}. Variety Bjanka showed the record root yield 126,54 tha^{-1} followed by Chiara (122,95 tha^{-1}), Concerto (122,40 tha^{-1}), Alvira (121,14 tha^{-1}) and others. The lowest root yield was recorded for Hi 0135 (101,82 tha^{-1}). The most marked difference obtained was between the first-ranked (Bjanka 126,54 tha^{-1}) and the last-ranked (Hi 0135 101,82 tha^{-1}) being 24,72 tha^{-1} or 19,54%.

Remos was among the highest in the percentage of sugar (16,46%). Hi 0135 (16,22%), Dorotea (16,17%), Opera (16,13%) and Lion 06 YU (16,05%) followed. The lowest was for Chiara (15,12%). The most marked difference was 1,34% absolute or 8,14% relative.

The average percentage of sugar for this trial was high (15,82%). The cultivars showed good stands for other quality parameters, too. The best processing quality was recorded for Remos and Leila because of the highest percentage of sugar utilization (89,0%).

Remos had the record crystalline sugar yield (17,458 tha^{-1}), followed by Bjanka (17,018 tha^{-1}), Lion 06 YU (16,768 tha^{-1}), Esprit (16,690 tha^{-1}), Stru 2206 (tha^{-1}), Alvira (16,633 tha^{-1}), with the lowest yield for Rama (13,676 tha^{-1}). The most marked difference in crystalline sugar yield between the first-ranked (Remos 17,458 tha^{-1}) and the control (14,771 tha^{-1}) was not so high and amounted to 2,687 tha^{-1} or 15,40%.

DISCUSSION

The average root yields were 72,46 tha^{-1} at Kikinda and 114,40 tha^{-1} at Sombor, ranging from 12,00 tha^{-1} (Kikinda) to 101,82 tha^{-1} (Sombor). Thus, high variation in root yields was observed depending on the locality and variety. Similar results were reported by Glattkowski et al. (1994) and Marlender and Rothe (2005).

The variation in the percentage of sugar, averaged across sires was 1,68% absolute. The most marked difference among varieties depending on locality was 4,45% at Kikinda and 1,34% at Sombor. Similar results were published by Radivojević et al. (1999), Kovačev et al. (2003) and Hofmann et al. (2002).

The variation in crystalline sugar yield within varieties was also rather extreme: 8,363 tha^{-1} (90,85%) at Kikinda and 3,782 tha^{-1} (21,665) at Sombor. These findings are consistent with those reported by Buttner and Mangold (1998) and many other researchers.

CONCLUSION

Significant variation in root yield, sugar content and crystalline sugar content depending on soil infestation with *Rhizomania* was found.

On **soil affected by** *Rhizomania* (at Kikinda site), the variability of quality parameters was as follows:

— **Root yield** varied from 12,00 tha^{-1} to 85,78 tha^{-1} or 7,15 times or 73,78 tha^{-1};

— **Percentage of sugar** on beet varied from 10,93% to 15,36% or 4,45% absolute or 29,0% relative;

— **Crystalline sugar yield** varied from 0,842 tha^{-1} to 9,205 tha^{-1} or 10,93 times.

On sound soil (not infested with *Rhizomania*) at Sombor site, the variability of the quality parameters was as follows:

— **Root yield** varied from 101,82 tha^{-1} to 126,54 tha^{-1} or 19,54%;

— **Percentage of sugar** on beet varied from 15,12% to 16,46% or 1,34% absolute or 8,14% relative;

— **Crystalline sugar yield** varied from 13,676 tha^{-1} to 17,458 tha^{-1} or 21,66%.

In order to achieve high and stable yields and good processing quality of sugar beet, the producers should analyse the soil on the presence of *Rhizomania* and choose cultivars highly tolerant to it.

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Table 1: Average monthly temperatures in 2004 (T) and temperature deviations (A) from the means over the seasons 1975—2000.

No.	Locality	Month														Average in veget. period	
		April		May		June		July		August		September		October			
		T	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A
1	Kikinda	12,1	+0,7	15,2	–1,3	20,0	+0,4	22,2	+1,0	21,6	+0,5	16,4	–0,9	14,0	+1,8	17,3	+0,3
2	Sombor	12,0	+0,6	15,2	–1,3	19,7	+0,1	21,6	+0,4	21,5	+0,4	16,3	–1,0	13,9	+1,7	17,2	+0,2
Average		12,1	+0,7	15,2	–1,3	19,9	+0,3	21,9	+0,7	21,6	+0,5	16,4	–0,9	14,0	+1,8	17,3	+0,3
Several-year temperature average (°C) (1975—2000)		11,4		16,5		19,6		21,2		21,1		17,3		12.2		17,0	

Table 2: Average monthly rainfall in 2004 (R) and deviations (A) from the means over the seasons 1975—2000 expressed as surplus (+), deficit (–), winter, vegetation, total rainfall.

	Locality	Winter precipi-tation (XI-III)	April		May		June		July		August		Septemb.		Octobar		Total rainfall over veg. period (IV—X)		Total yearly rainfall (XI-X)	
			R	A	R	A	R	A	R	A	R	A	R	A	R	A	R	A	R	A
1	Kikinda	164,0	105,0	+60,2	23,0	–32,2	60,0	–16,2	68,0	+7,1	52,0	+0,3	40,0	–6,0	41,0	–2,2	389,0	+11,0	553,0	–21,4
2	Sombor	186,0	110,0	+65,2	107,0	+51,8	73,0	–3,2	107,0	+46,1	34,0	–17,7	54,0	+8,0	86,0	+42,8	571,0	+193,0	757,0	+182,6
Average		175,0	107,5	+62,7	65,0	+9,8	66,5	–9,7	87,5	+26,6	43,0	–8,7	47,0	+1,0	63,5	+20,3	480,0	+102,0	655,0	+80,6
Several-year average of monthly rainfall (1975—2000)		196,4	44,8		55,2		76,2		60,9		51,7		46,0		43,2		378,0		574,4	

Table 3. Sugar beet field-trial results at Kikinda in 2004.

No.	Variety	Root yield (t/ha)	Sugar content (%)	Sugar utilization % on beet	Polarized sugar yield (t/ha)	Crystalline sugar yield (t/ha)
1	Dorotea	77,45	13,89	10,29	10,749	7,953
2	Chiara	81,49	13,17	9,46	10,718	7,691
3	Lion 06 YU	75,41	13,94	10,44	10,518	7,873
4	Donna	78,80	14,66	11,44	11,550	9,014
5	Sofarizo	80,27	14,78	11,47	11,859	9,196
6	Aleksinac-R	74,10	13,69	9,80	10,153	7,271
7	Opera	66,69	13,94	10,39	9,287	6,915
8	Porto	77,51	14,15	10,62	10,971	8,238
9	Esprit	76,88	14,41	11.04	11,079	8,483
10	Remos	77,82	14,93	11,83	11,619	9,205
11	Concerto	85,78	14,11	10,32	12,098	8,843
12	Alvira	77,80	13,12	9,61	10,194	7,464
13	Libero	81,24	14,10	10,60	11,453	8,613
14	Leila	70,69	15,17	12,05	10,727	8,524
15	Merak	76.84	14,48	11,15	11,116	8,555
16	Ivona	58,65	15,36	12,05	9,011	7,066
17	Rama	69,08	14,65	11,26	10,115	7,769
18	Hi 0135	69,94	14,29	11,09	9,982	7,739
19	Strube 2206	74,94	15,19	12,21	11.376	9,143
20	Bjanka	78,22	13,83	10,39	10,808	8,122
21	Control	12,00	10,91	7,00	1,311	0,842
Mean.		72,46	14,13	10,69	10,319	7,834
LSD	0,05	6,97	0,41	0,47	0,971	0,741
	0,01	9,24	0,55	0,62	1,288	0,983
Cv	(%)	21,55	7,01	11,17	22,06	22,88

Table 3 continued: Sugar beet field-trial results at Kikinda in 2004.

No	Variety	Q Thick juice	Sugar in molasses % on beet	K	Na	α-amino N
				mmol/°S		
1	Dorotea	85,91	3,00	38,19	22,12	33,93
2	Chiara	84,79	3,11	35,95	29,82	36,34
3	Lion 06 YU	86,07	2,90	32,69	24,70	35,74
4	Donna	87,30	2,62	30,68	17,74	36,12
5	Sofarizo	87,48	2,71	31,18	19,46	32,61
6	Aleksinac-R	83,55	3,29	40,58	23,36	46,84
7	Opera	86,24	2,95	32,97	26,35	32,61
8	Porto	86,08	2,93	33,80	22,96	36,27
9	Esprit	86,65	2,77	31,95	20,55	36,54
10	Remos	88,16	2,50	32,69	13,32	32,48
11	Concerto	85,65	3,19	36,18	27,30	32,63
12	Alvira	85,77	2,91	33,73	29,02	32,46
13	Libero	86,47	2,90	33,59	23,76	33,02
14	Leila	88,02	2,52	28,93	16,16	34,41
15	Merak	86,99	2,73	32,59	19,01	35,09
16	Ivona	87,67	2,71	34,78	13,28	33,84
17	Rama	86,50	2,79	34,36	16,77	38,97
18	Hi 0135	87,51	2,60	29,91	20,61	32,55
19	Strube 2206	88,35	2,38	30,58	11,55	35,03
20	Bjanka	86,21	2,84	36,64	19,99	35,52
21	Control.	82,71	3,31	48,59	40,71	27,40
Mean		86,38	2,84	34,31	21,83	34,78
LSD	0,05	0,76	0,14	2,32	3,22	3,33
	0,01	1,00	0,18	3,08	4,27	4,42
Cv	(%)	1,77	9,43	13,34	31,81	13,31

Table 4. Sugar beet field-trial results at Sombor in 2004.

No.	Variety	Root yield (t/ha)	Sugar content (%)	Sugar utilization % on beet	Polarized sugar yield (t/ha)	Crystalline sugar yield (t/ha)
1	Dorotea	117,68	16,17	14,03	19,022	16,498
2	Chiara	122,95	15,12	12,71	18,595	15,632
3	Lion 06 YU	119,95	16,05	13,97	19,254	16,768
4	Donna	110,43	16,02	13,93	17,693	15,383
5	Sofarizo	105,44	15,98	13,82	16,856	14,577
6	Aleksinac-R	111,89	15,20	12,58	17,009	14,087
7	Opera	112,37	16,13	14,11	18,117	15,852
8	Porto	109,57	15,54	13,28	17,032	14,551
9	Esprit	119,56	16,04	13,97	19,168	16,690
10	Remos	118,92	16,46	14,67	19,587	17,458
11	Concerto	122,40	15,74	13,32	19,271	16,316
12	Alvira	121,14	15,76	13,74	19,094	16,633
13	Libero	115,16	15,84	13,96	18,259	16,103
14	Leila	113,16	15,99	14,22	18,086	16,094
15	Merak	107,29	15,91	14,05	17,069	15,076
16	Ivona	111,24	15,70	13,70	17,467	15,238
17	Rama	104,75	15,17	13,06	15,892	13,676
18	Hi 0135	101,82	16,22	14,06	16,515	14,321
19	Strube 2206	119,38	15,85	13,95	18,921	16,659
20	Bjanka	126,54	15,61	13,44	19,757	17,018
21	Control.	110,69	15,41	13,34	17,063	14,771
Mean		114,40	15,81	13,71	18,082	15,686
LSD	0,05	7,32	0,38	0,44	1,256	1,155
	0,01	9,70	0,51	0,58	1,666	1,532
Cv	(%)	7,42	2,88	4,50	8,07	8,78

Table 4 continued: Sugar beet field-trial results at Sombor in 2004.

No	Variety	Q Thick juice	Sugar in molasses % on beet	K	Na	α-amino N
				mmol/°S		
1	Dorotea	93,07	1,54	23,99	5,31	14,81
2	Chiara	91,67	1,81	29,09	6,88	17,92
3	Lion 06 YU	92,93	1,48	23,75	3,96	17,32
4	Donna	92,73	1,49	24,76	2,96	18,76
5	Sofarizo	92,42	1,56	23,83	4,83	19,99
6	Aleksinac-R	90,11	2,02	32,55	4,45	27,80
7	Opera	93,13	1,42	21,82	4,69	17,17
8	Porto	92,15	1,66	27,54	4,47	18,52
9	Esprit	92,78	1,47	23,61	3,63	18,90
10	Remos	93.96	1,19	20,72	1,72	15,39
11	Concerto	91,84	1,81	28,47	6,02	18,23
12	Alvira	92,89	1,43	21,82	5,28	18,24
13	Libero	93,44	1,28	21,61	3,04	16,84
14	Leila	93,88	1,17	18,82	3,73	15,86
15	Merak	93,40	1,26	20,75	3,02	18,01
16	Ivona	92,67	1,40	22,93	3,05	20,90
17	Rama	92,22	1,51	25,94	3,44	20,63
18	Hi 0135	92,58	1,56	23,31	4,93	19,29
19	Strube 2206	93,18	1,30	22,39	2,01	18,91
20	Bjanka	92,09	1,57	25,52	3,64	21,80
21	Control	92,24	1,47	23,55	4,10	22,26
Mean		92,64	1,49	24,13	4,05	18,93
LSD	0,05	0,56	0,12	1,93	0,98	2,60
	0,01	0,74	0,16	2,56	1,30	3,44
Cv	(%)	1,13	17,24	16,62	36,14	19,15

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ВАРИРАЊЕ ПРИНОСА КОРЕНА И ШЕЋЕРА И ТЕХНОЛОШКОГ КВАЛИТЕТА ШЕЋЕРНЕ РЕПЕ У ЗАВИСНОСТИ ОД СОРТЕ И ЗАРАЖЕНОСТИ ЗЕМЉИШТА РИЗОМАНИЈОМ

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Резиме

У току 2004. године изведена су два сортна микроогледа са сортама шећерне репе различите толерантности на ризоманију. Микроогледи су били постављени у Пољопривредној станици у Кикинди, где је утврђен висок степен заразе на ризоманију и у „Агроинституту” у Сомбору, где она није била установљена. На оба микроогледа биле су засејане исте сорте шећерне репе, укупно двадесет и једна, са различитим степеном толерантности на ризоманију. Засејане сорте шећерне репе припадале су различитим селекционим компанијама које су заступљене код нас.

Кретање приноса корена шећерне репе на микороогледу у Кикинди, износило је од 85,78 t ha^{-1} код сорте Concerto до свега 12,00 t ha^{-1} код контроле, не-

толерантне на ризоманију. Остварена разлика, у наведеном показатељу, износила је 73,78 t ha^{-1}, односно 86,01%. Утврђена разлика у садржају шећера између прворангиране сорте Ивона (15,36%) и контроле (10,91%) износила је 4,45% апсолутних. Међутим, установљена разлика у приносу кристалног шећера између прворангиране сорте Remos (9,205 ha^{-1}) и контроле (од свега 0,842 t ha^{-1}) износила је 8,363 t ha, или 90,85%.

На другом локалитету, у Сомбору, установљене екстремне разлике између испитиваних сорти биле су значајно ниже, али такође доста изражене.

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RHIZOCTONIA ROOT ROT (*RHIZOCTONIA SOLANI* KÜHN.) OF SUGAR BEET IN PROVINCE VOJVODINA*

ABSTRACT: Sugar beet root rot appears regularly each year, but its intensity depends on agro ecological conditions. The predominant causers of root rot in Vojvodina are fungi from *Fusarium* genus and species *Macrophomina phaseolina*. Over the last couple of years, more intense occurrence of *Rhizoctonia* root rot has been observed.

Rhizoctonia solani, the causal agent of root rot is present in sugar beet fields. During 2000—2005, on the territory of Vojvodina, the frequency of *Rhizoctonia solani* in phytopathological isolations from rotted sugar beet roots was between 0,0—18,2%. The intensity of the disease depends on localities, agro ecological conditions and genotypes.

Symptoms of *Rhizoctonia* root rot were registered at some localities in all regions of Vojvodina: Srem, Banat and Bačka. The disease appearance is above all local. It occurs in small patches, on heavy, non-structured soil and on depressed, wet parts of plots. Individual diseased plants can be found during July. Brown rot appears on sugar beet roots, with dried tissue on surface, which is present on the tail as well as on the middle part and the head of root. Tissues with described symptoms are deeper regarding the healthy part of root. On vertical root section, the necrotic changes are clearly visible comparing to tissue section without symptoms. The heavily infected tissue forms fissures on roots in most cases. Besides the above-mentioned symptoms on roots, the plant wilting and leaf handle necrosis as well as leaf dying are also observed. When rot spreads to the whole root head, plants quickly die.

KEY WORDS: distribution, aetiology, *Rhizoctonia* root rot, *Rhizoctonia solani*, sugar beet, Vojvodina

INTRODUCTION

Various types of rot on sugar beet root have become more and more frequent in the last couple of years and have caused economically significant losses in our country (Stojšin, 2003, Marić and Stojšin, 2004).

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There are a lot of available data on parasites that cause root rot. The first noteworthy occurrence and greater losses were registered during 1960s in Banat and the north part of Bačka (M a r i ć et al., 1970). Later, in the last decade of 20th and at the beginning of 21st century, root rot occurred, usually in dry years, when it caused economically significant losses which manifested in decrease of yield and digestion. According to many authors (M a r i ć et al., 1970, S t o j š i n et al. 2001, J a s n i ć et al., 2001, J a s n i ć et al., 2004, P e j o v i ć et al., 2003, M a r i ć and S t o j š i n, 2004, S t o j š i n, 2003), *Fusarium* root rot is the most important root disease in our country. This one, together with charcoal root rot (*Macrophomina phaseolina*) causes huge damages on sugar beet, especially in dry years (M a r i ć et al., 1970, S t o j š i n, 1993, S t o j š i n, et al., 1999). Other species like *Thanatephorus cucumeris* (anamorphic *Rhizoctonia solani*) — *Rhizoctonia* root rot, *Erwinia carotovora* — causal agent of bacterial soft rot, *Streptomyces scabies* — the causal agent of scab root, *Pleospora bjoerlingii* (anamorphic *Phoma betae*) — seedling damping-off, etc. appear from time to time on individual plots or isolated plants and they are not harmful to sugar beet in Vojvodina (M a r i ć and S t o j š i n, 2004). Nevertheless, some authors claim that *Rhizoctonia* root rot (*Rhizoctonia solani*) is spread in Vojvodina and that it can cause significant losses in some years, especially in Srem (V i c o et al., 2004).

MATERIAL AND METHODS

Collecting root samples

Root rot was evidenced in more localities in Vojvodina and was being followed during vegetative periods in years from 2000 to 2005. In order to diagnose and identify the cause of root rot and to examine symptoms of decay, sample roots with symptoms of the rot were collected from different localities. The roots were selected randomly and the part of roots with typical symptoms was used for isolation and determination of parasites that cause rot.

Isolation

Phytopathological isolations were done by standard procedure, which means isolation on Potato Dextrose Agar (PDA) medium, in Petri dishes and incubation in thermostat at 25°C. After the colony development, isolates were transferred in order to get pure cultures and to determine the fungus.

Determination

Isolates were determined as *Rhizoctonia solani* on the base of morphology of vegetative and generative organs (B a r u c h, S. et al., 1998).

THE RESULTS AND DISCUSSION

Phytopathological isolations

During experimental period, *Fusarium* species were predominant pathogenes which caused sugar beet root rot in Vojvodina (40,8%). Species like *Macrophomina phaseolina* (2,86%), *Rhizoctonia solani* (8,94%) and other fungi genera were registered in lower percentage (19,76%) (Table 1).

Table 1. Isolation from diseased sugar beet roots in different locations in Vojvodina (2000—2004)

Year	Number of diseased roots	Isolated fungi (%)			
		Fusarium spp.	*R. solani*	*Macrophomina phaseolina*	Others saprophytic organisms
2000	99	68,8	0,0	2,5	6,0
2001	30	16,7	10,0	0,0	6,7
2002	60	26,3	4,7	4,7	48,3
2003	30	61,3	11,8	7,1	23,3
2004	55	30,9	18,2	0,0	14,5
Average	54,8	40,8	8,94	2,86	19,76

Symptoms of Rhizoctonia *root rot*

The first symptoms which could be noticed on diseased plants are sudden chlorosis and wilting of leaves. Black necrosis of leaf stems appear, especially on leaves close to the root head. Faded, wilted leaves quickly collapse and form brown to black rosette, which is present throughout the whole vegetative period. Root rot can be complete or partial. Brown to black parts of tissue appear on diseased root. They can unify and capture one part or the whole root. Deep fissures are usually located near the head of the root. In humid conditions, tissue can soften and symptoms of wet rot are present then. Another type of symptom is dry rot, which manifests itself in lesions which are light and dark brown, in the shape of concentric circles. Under the lesions, parasite mycelium is formed with clearly distinguished margins between healthy and diseased tissue.

DISCUSSION

Intensity of *Rhizoctonia* root rot depends on the large number of biotic and abiotic factors. The degree of disease caused by *R. solani* depends on the amount of inoculum in the soil, time of infection, environmental conditions (temperature and humidity) and include physical, chemical and biological characteristics of the soil (B u d d e r m e y e r and P e t e r s e n, 2004). *Rhizoctonia* root rot more frequently appears on heavy, non-structured soils as well as on depressed, wet parts of the soil with high level of underground water. Parasite causes greater losses when sugar beet is grown (B u d d e r m e y e r and P e t e r s e n, 2004) in monoculture (inadequate crop rotation) or in frequent breeding on one parcel only (M a r i ć, 1992, B u d d e r m e y e r and P e t e r s e n, 2004, W e s t e r d i j k et al., 2004). Therefore, concerning all these reasons, it is necessary to use integrated control to fight *Rhizoctonia* root rot, caused by *R. solani*. These means that control should include improved cultivation practice, then the use of fungicides as well as biological means of control against the disease.

One of the most important measures concerning cultivation practice is crop rotation. On the parcels where sugar beet is grown in monoculture, the percentage of *Rhizoctonia* root rot is significantly higher, while on those parcels with preceding cereal crops (wheat or barley) or grasses, the frequency of diseased plants is much lower (W e s t e r d i j k et al., 2004).

On compacted soil the intensity of the disease is higher. That is why soil impacting and compressing should be avoided. Soil for sugar beet breeding needs to be loose and well-aerated.

Also, it is recommended to breed resistant sugar beet variants, since the resistant genotypes exist. However, environmental conditions and the amount of inoculum can effect the resistance degree. Seedlings of resistant sugar beet variants are usually very susceptible to the parasite (W e s t e r d i j k et al., 2004). With the purpose of seedling protection chemical measures are recommended. These measures include fungicide treatment of the seeds as well as chemical treatments of young plants. The treatment of young plants with the fungicides on the basis of strobilurin (active substance is azoxystrobin, commercial product Quadris) turned out to be a very successful one. According to the results of S t u m p and F r a n c (2003), the use of strobilurin decreases the appearance of root rot in 41—81% and increases yield 3—4 times comparing to non-treated control in the conditions of artificial inoculation of sugar beet in field. Seed treatment with protective fungicides (Maneb, Mankozeb and Tiram) is efficient in seedling protection.

Biological measures against damping-off and flattening of the seedlings, since they are non-resistant to *R. solani* are usually recommended and they include seed treatment with spore suspension of *Trichoderma virens* fungus. Some of these isolates express high efficiency against seedling damping-off (H a n s o n, 2003). It is well known that fungus from *Trichoderma* genus form antibiotics, which inhibit the development of other fungi species (H o w e l l et al., 1993). *T. harzianum* manifests activity against *Rhizoctonia* root rot, but it does not affect damping-off and flattening of seedlings (R u p p e l et al., 1983).

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RHIZOCTONIA SOLANI KÜHN. ПРОУЗРОКОВАЧ МРКЕ ТРУЛЕЖИ КОРЕНА ШЕЋЕРНЕ РЕПЕ У ВОЈВОДИНИ

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Резиме

Трулеж корена шећерне репе јавља се сваке године у слабијем, или јачем интензитету, пре свега у зависности од агроеколошких услова. Доминантни проузроковачи трулежи корена шећерне репе у нашој земљи су гљиве из рода *Fusarium* и *Macrophomina phaseolina*. Последњих година уочена је интензивнија појава мрке трулежи корена шећерне репе проузроковане од стране *Rhizoctonia solani*.

Rhizoctonia solani, проузроковач мрке трулежи корена, присутна је на пољима под шећерном репом. У периоду 2000—2005. на територији Војводине заступљеност гљиве *Rhizoctonia solani* у фитопатолошким изолацијама из корена са симптомима трулежи била је у интервалу 0,0—18,2%. Интензитет појаве обољења зависи од локалитета, временских услова и генотипа.

Симптоми мрке трулежи корена регистровани су на појединим локалитетима Срема, Баната и Бачке. Обољење се пре свега јавља локално, у мањим оазама на парцелама, на тежим неструктурним земљиштима, као и забареним деловима њива. Појединачне оболеле биљке се налазе током јула. На корену шећерне репе јавља се тип симптома мрке, суве трулежи на површини ткива, која се јавља како на репном, тако и на средњем делу и глави корена. Ткиво са описаним симптомима је угнуто у односу на здраво. На уздужном пресеку корена уочава се смена мрког, некротичног ткива, са ткивом без видљиве промене боје. Јаче заражено ткиво код већег броја узорака пуца стварајући пукотине на корену. Поред описаних симптома, уочава се и пад тургора, некроза и трулеж основа лисних дршки и сушење лишћа. Када трулеж захвати читаву главу корена, биљке убрзо угињавају.

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MULTINUCLEATE *RHIZOCTONIA* SP. — PATHOGEN OF SUGAR BEET AND SUSCEPTIBILITY OF CULTIVARS UNDER FIELD CONDITIONS*

ABSTRACT: Sugar beet root rot has severely occurred in our country recently, especially in localities of Pazova, Pećinci, Ruma, Sremska Mitrovica and Šid. From diseased roots as well as from soil collected from the localities where decay occurred, fungal isolates were obtained by bait plant method. Based on their characteristics, they were identified as multinucleate *Rhizoctonia* sp.

During the year of 2004 in Mitrosrem trial field T-11, where the presence of multinucleate *Rhizoctonia* sp. was confirmed, an experiment under the coordination of Committee for Acknowledgement and Registration of New Cultivars in our country was conducted in order to determine cultivars' tolerance, i.e. their susceptibility and possibility for growing on infested fields. Six cultivars of sugar beet, Laetitia (as standard) and five new ones were included in the investigation. The trial was conducted in accordance with the established and accepted method (Ministry of Agriculture, Forestry and Water Resources, Republic of Serbia). Susceptibility of investigated cultivars was evaluated according to significant production characteristics: root yield, sugar content, corrected sugar content, thick juice Q, molasses sugar, content of K, Na and amino-N, polarized sugar yield and white sugar yield, as it was recommended by the method.

Conducted investigations have revealed that tested sugar beet cultivars showed different reactions to natural infection with multinucleate *Rhizoctonia* sp. Concerning root yield as the most important agricultural characteristic, statistically significantly higher yield was obtained with the cultivar under code mark 5 (61.120 kg/ha), whereas the cultivar marked under code 6 had significantly lower yield comparing to the standard (38.100 kg/ha).

KEY WORDS: multinucleate *Rhizoctonia* sp., natural infection, tolerant cultivars, yield

* The paper was presented at the first scientific meeting IV INTERNATIONAL SYMPOSIUM ON SUGAR BEET Protection held from 26—28 september 2005 in Novi Sad.

INTRODUCTION

Rhizoctonia solani is the most studied species of *Rhizoctonia* genus and was described for the first time on potato in 1858 (S n e h et al., 1991). Based on the number of nuclei in their cells, fungi belonging to *Rhizoctonia* spp. can be divided in two groups: binucleate and multinucleate. Species described as *Rh. solani* has more than three nuclei in its cells, thus this species belongs to the group of multinucleate *Rhizoctonia* sp. According to new criteria in the taxonomy of *Rhizoctonia*, it is recommended to describe *Rh. solani* as multinucleate *Rhizoctonia* sp. (S n e h et al., 1996).

Multinucleate *Rhizoctonia* sp. is economically important for growing on numerous plant hosts worldwide and in our country it is common on potato, beans, alfalfa (V i c o et al., 1996), tomato, cabbage (I v a n o v i ć and I v a n o v i ć, 2001) and ornamentals (V i c o et al., 2005). Besides mentioned hosts, in several localities in our country, this fungus is proved to be causing sugar beet root rot (V i c o et al., 2004).

In localities of Pazova, Pećinci, Ruma, Sremska Mitrovica and Šid, massive decay of sugar beet has been observed. From diseased roots, as well as from the soil originating in these localities, fungus was isolated using plant bait method and was identified as multinucleate *Rhizoctonia* sp., based on some of its characteristics (V i c o et al., 2004). This fungus can survive as sclerotia or mycelia on plant debris in infested soil for a very long period (S c h e i d e r and W h i t n e y, 1986). Since it is polifagous, attacking numerous plant hosts, its inoculum accumulates in the soil although crop rotation is employed. In these conditions, after multinucleate *Rhizoctonia* sp. is registered in a certain locality, the only economically justified and available control measure is growing resistant or tolerant cultivars (H a r v e s o n, 2003).

The aim of described investigations was to examine reactions of some sugar beet cultivars to natural infection in order to evaluate their capacity for growing on soil infested by multinucleate *Rhizoctonia* sp.

MATERIAL AND METHODS

During 2003, on Mitrosrem field in Glac locality, near Sremska Mitrovica, where sugar beet rot had been noticed in previous years, five soil samples were collected. These samples, each consisting of 1 kg of soil, were investigated for the presence of plant pathogenic fungi using bait method (F o x, 1993). Soil was placed in appropriate pots and sowed with sugar beet, cv. Dana. After seedlings had emerged in greenhouse conditions, symptoms were observed each day. Greenhouse and phytopatological investigations were conducted in the facilities of Department of Phytopathology, Faculty of Agriculture, Belgrade, Zemun.

From bait plants-seedlings with disease symptoms, isolation by usual methods was performed on potato-dextrose agar (PDA). Previously superficially disinfected (1 min, 2% Natriumhipohlorit, NaClO) root and crown fragments were placed or immersed in PDA media. Incubation was at 23°C, in dark. After fungi were developed around the plant fragments, a colony fragment was transferred, first on fresh PDA and afterwards on water agar (WA) where hyphal tip isolates were obtained.

In order to identify the obtained fungal isolates, macroscopic and microscopic morphological, as well as some biological characteristics were investigated. Colony appearance and characteristics like shape, dimensions and characteristics of spores and mycelia, as well as the number of nuclei in cells were studied. On seven days old fungal colonies on PDA, incubated at 24°C in dark, macroscopic properties of isolates were studied, following the criteria proposed by Muntanola-Cvetković (1987). Studied properties were growth rate, colony appearance, colony edge characteristics, colour, the presence of fructifying bodies, exudation, scent and pigmentation. Seven days old fungal colonies on PDA and WA were used for observing and studying microscopic characteristics. Studied microscopic properties were mycelia appearance, hyphal appearance, branching and septation, characteristics of septae, sporulation, as well as the appearance of myceliar bodies. Hyphal width and the length from the branching point to the first septae and dimensions of spores and myceliar bodies were measured. The number of nuclei per cell in obtained isolates was investigated applying two methods: shafranin O staining (Bandoni, 1979) and staining with aniline blue in lactophenol (0,5% solution) (Burpee et al., 1978). The number of nuclei per cell was determined in 100 randomly selected hyphal or moniliformous cells in seven days old cultures of investigated isolates, grown on PDA and WA media.

During 2004 in the Mitrosrem field, in Glac locality, where multinucleate *Rhizoctonia* sp. presence was proved, a field experiment was set up, under the guidance of Committee for Acknowledgement and Registration of New Cultivars. Six sugar beet cultivars, Laetitia (as standard) as well as five new ones were included in the investigation. The experiment was set up in accordance with the recommended and accepted methodology of Cultivar Committee (Ministry of Agriculture, Forestry and Water Resources, Republic of Serbia). It was designed in five replications according to random block system. Sugar beet was planted at the beginning of April 2004, in the rows, 50 cm apart with 20 cm distance between plants in one row. During vegetation, usual agricultural and disease control measures were applied. Root harvesting was manual, at the beginning of October. The number of plants per experimental plot was calculated and expressed in 000/ha. Yield was measured and roots were then transported to Laboratory of Sugar Technology Department, Faculty of Food Technology, Novi Sad. Evaluated tolerance of investigated sugar beet cultivars was based on significant productional characteristics such as the number of harvested plants, root yield, sugar content, corrected sugar content, thick juice Q, molasses sugar, K, Na, and amino-N content, polarized sugar yield and white sugar yield, as it is recommended by the method. Obtained results were statistically analysed as separate monofactorial trials according to random block system. Pair evaluations were calculated using LSD test at 0,05 and 0,01 levels of significance.

RESULTS

Symptoms on bait plants and identification of fungi

On diseased sugar beet seedlings, 7—10 days after emerging, damping off occurred as the result of root and crown necrosis (Figure 1). From diseased bait plants with symptoms of necrosis, fungus was isolated on PDA. After obtaining hyphal tip cultures, the identification was carried out.

Isolates expressed following macroscopic characteristics: beige to brown colonies, rich and well developed showing rapid growth (average 24,55 mm per day); edge uninterrupted and smooth; mycelium developed on the glass; sclerotia (numerous, thick, spherical, light to dark brownish, usually in groups, 0,5—3 mm in diameter) were formed superficially in the colonies, 5—6 days after transferring to PDA and usually distributed near colony edge (Figure 2).

Microscopic properties of investigated isolates were: mycelia wavy and multicelullar; young hyphae branching under almost right angle; at the branching point, where lateral hyphae began to grow, there was a characteristic narrow point near which septae could be found on the lateral branch (Figure 3); moniliformous cells appeared in long chains (Figure 4). Hyphal width was from 5,5—7,5 μm, hyphal length from the branching point to the first septae was 4,7—7,5 μm, hyphal width at the narrow point was 4,5 μm on average.

Symptoms during vegetation

During the field trial, complete plant decay was found in some sugar beet cultivars. On a few of the remaining plants there were symptoms of rot which could be seen during harvesting, at the end of the experiment. Symptoms on mature plants were dark brown necrosis and superficial root splitting (Figure 6). Necrosis and rot were spreading towards root core. Plant decay and root rot were observed in different intensity on investigated sugar beet cultivars. During root harvesting, a similar number of 1—4 rotted roots per replicate was established with cultivars under codes 2, 4 and 5, while the cultivar under code 6 had 17—20 roots with symptoms. Nevertheless, all investigated sugar beet cultivars expressed similar capability of finishing vegetation in the soil infested with multinucleate *Rhizoctonia* sp. (Figure 5). The number of harvested plants was not statistically different comparing to the standard. The only exception was the cultivar under code 5 where statistically significantlly higher number of plants completed the vegetation (Table 1).

Productional properties of investigated sugar beet cultivars

In the conditions of natural infection with multinucleate *Rhizoctonia* sp., sugar beet cultivars expressed different productional properties and the results were summarised in Table 1.

As it can be seen in Table 1, the highest yield was recorded for the cultivar under code 5 (61,120 kg/ha) and this was statistically significantlly higher comparing to the standard, cv. Laetitia, which was under code 1. The lowest yield was recorded for the cultivar under code 6 (38100 kg/ha) and this was statistically significantlly lower than the standard. The highest sugar content was found in the cultivar under code 3 (15,58%), followed by the cultivar under code 5 (15,40%). Both were statistically significantlly higher comparing to the standard. Remaining cultivars, 2, 4 and 6 also had statistically significantly higher sugar content comparing to Laetitia (14,17%). Concerning plant number per ha, the only statisticaly significant difference comparing to the standard was with the cultivar under code 5 where the higher number of plants managed to complete vegetation (95400 plants/ha).

In Table 2, the remaining productional characteristics were summarized. Among these, the important ones are polarized sugar yield and white sugar yield which were the highest with the cultivar under code 5 (5418 and 7904 kg/ha, respectively) and the lowest with the cultivar under code 6 (5759 and 4830 kg/ha, respectively).

DISCUSSION

Obtained fungal isolates were identified as multinucleate *Rhizoctonia* sp. based on disease symptoms on bait plants, i.e. sugar beet seedlings, isolation and morphological properties as well as on the number of nuclei in the cells (Sneh et al., 1991; Ceresini, 1991). The presence of plant pathogenic fungi *Rhizoctonia* sp. was confirmed in the soil of Mitrosrem T-11 field, which made it appropriate for setting the cultivar experiment.

During vegetation, with all investigated sugar beet cultivars, necrosis and decay of smaller number of plants were established. Not all the plants that had been planted and then emerged, managed to complete vegetation. Multinucleate *Rhizoctonia* sp. is the causal agent of necrosis and decay of sugar beet, causing yield reduction by 2—30% (Scheider and Whitney, 1986) and even up to 50% (Galliann, 1998). This yield reduction is greatly due to plant decay before harvesting. In the conditions of this experiment, with all investigated sugar beet cultivars, a large number of plants was able to finish vegetation, so all investigated cultivars posses a certain level of tolerance towards *Rhizoctonia* sp. and the capacity to be cultured in infested soil.

For evaluating the capability of sugar beet cultivars to grow in infested soil, productional properties such as yield and sugar content proved to be appropriate. These two parameters separated investigated cultivars and emphasised differences between them on the level of significance LSD 0.05 and 0.01. The cultivar under code 5 had statistically significantly higher yield in the conditions of this experiment and statistically very significantly higher sugar content comparing to the cultivar Laetitia which represented the standard as an acknowledged tolerant sugar beet cultivar. The selection of new sugar beet cultivars tolerant against multinucleate *Rhizoctonia* sp. and their introduction into practice represent an intensive research field in the world. Leonard and H a n s o n (2003) recommend yield measurement and disease intensity assessment as tools for selecting tolerant sugar beet genotypes in the conditions of natural infection. L e o n a r d (2003) examined the tolerance of sugar beet cultivars against multinucleate *Rhizoctonia* sp., but cultivar reaction was compared to a susceptible standard. In that way, the reaction of tolerant cultivars was more obvious. Based on the results obtained in this investigation and comparing them to literature data, sugar beet cultivar under code 5 could be recommended for further evaluations, because it showed statistically significantly higher yield and statistically very significantly higher sugar content than the standard.

Results obtained in conducted investigations showed that tolerant sugar beet cultivars are available and able to give satisfactory yield in the conditions of soil infestation with multinucleate *Rhizoctonia* sp. in our climate. Since the growing of tolerant sugar beet genotypes on infested soil is the only economically justified control measure of sugar beet root rot caused by multinucleate *Rhizoctonia* sp., results obtained in presented investigations are significant for scientific as well as for practical aspects of sugar beet production.

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Table 1. Major productional characteristics of investigated sugar beet cultivars naturally infected with multinucleate *Rhizoctonia sp.* during 2004.

Sugar beet cultivars	Root yield (t/ha)	Plant No (000/ha)	Sugar content (%)
1	50,80	83,00	14,1667
2	59,64	92,60	14,9500*
3	50,28	87,00	15,5833**
4	53,52	93,00	14,8833*
5	61,12*	95,40*	15,4000**
6	38,00*	79,40	15,1000*
LSD 0.05	10,08044	9,959461	0,672487
LSD 0.01	13,75012	13,5851	0,956532
CV	14,65922%	8,588364	2,462034

Note:
* Statistically significant difference comparing to standard with LSD 0,05.
** Statistically significant difference comparing to standard with LSD 0,01.

Table 2. Other measured productional characteristics of investigated sugar beet cultivars naturally infected with multinucleate *Rhizoctonia* sp. during 2004.

Sugar-beet cultivars	Corrected sugar content %	Thick juice Q	Molasses Sugar %	K	Na	Amino N	Polarized sugar yield 000 kg/ha	White sugar yield 000 kg/ha
				mmol/100°S				
1	11,28	90,68	2,29	30,05	20,66	10,14	7,120	5,668
2	11,66	92,54	1,69	25,09	10,72	11,95	8,915	7,548
3	13,46	93,63	1,52	23,11	8,85	8,22	7,833	6,769
4	12,44	92,42	1,84	24,41	15,15	9,07	7,963	6,657
5	12,92	92,51	1,88	24,36	14,74	8,90	9,418	7,904
6	12,68	92,44	1,82	24,41	14,11	9,96	5,759	4,830

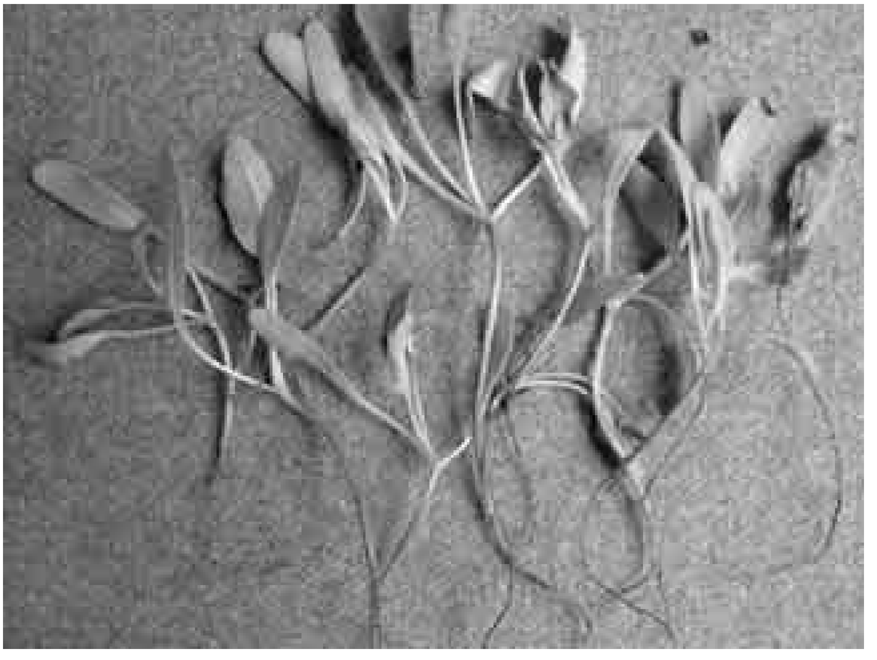

Figure 1. Multinucleate *Rhizoctonia* sp.: Root necrosis of bait plants

Figure 2. Multinucleate *Rhizoctonia* sp.: Sclerotia on colony edge on PDA

Figure 3. Multinucleate *Rhizoctonia* sp.:
Junction point of branching hyphae

Figure 4. Multinucleate *Rhizoctonia* sp.: Moniliformous cells, detail

Figure 5. Multinucleate *Rhizoctonia* sp.: Multiple nuclei in the hyphal cells

Figure 6. Multinucleate *Rhizoctonia* sp.: Necrosis and splitting on sugar beet roots

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ВИШЕЈЕДАРНА *RHIZOCTONIA* SP. — ПАТОГЕН ШЕЋЕРНЕ РЕПЕ И ОСЕТЉИВОСТ СОРТИ У ПОЉУ

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Резиме

Последњих година уочено је масовно пропадање шећерне репе у нашој земљи и то у локалитетима Пазове, Пећинаца, Руме, Сремске Митровице и Шида. Из оболелих коренова и из земљишта прикупљеног са терена где је пропадање уочено, методом мамака изолована је гљива која је по својим особинама идентификована као вишеједарна *Rhizoctonia* sp.

У току 2004. године на парцели Митросрема Т-11, где је изолацијом доказано присуство вишеједарне *Rhizoctonia* sp., постављен је оглед у оквиру сортне комисије за признавање и регистрацију нових сорти у нашој земљи са циљем утврђивања толерантности, односно осетљивости појединих сорти и тиме њихове погодности за гајење на инфестираном земљишту. У испитивања је укључено 6 сорти шећерне репе: *Laetitia* (као стандард) и још пет нових сорти. Оглед је посејан по утврђеној и прихваћеној методи сортне комисије (Министарство пољопривреде, шумарства и водопривреде Републике Србије). Осетљивост испитиваних сорти оцењивана је на основу значајних производних особина: принос корена, поларизација, кориговани садржај шећера, Q густог сока, садржаја сећера у меласи, садржаја K, Na и амино N, принос поларизационог шећера и принос кристалног шећера, како то метода и захтева.

На основу обављених истраживања установљено је да се испитиване сорте шећерне репе различито понашају у условима природне заразе вишеједарном *Rhizoctonia* sp. У погледу приноса, као најважније производне карактеристике, статистички значајно виши принос од стандарда испољила је сорта која се води под шифром 5 (61.120 kg/ha), док је сорта која се води под шифром 6 имала статистички значајно нижи принос у поређењу са стандардом (38.100 kg/ha).

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ROOT ROT DISEASES OF SUGAR BEET (*BETA VULGARIS* L.) AS AFFECTED BY DEFOLIATION INTENSITY*

ABSTRACT: The aim of this work was to study the effect of sugar beet re-growth after water stress defoliation on root rots of three cultivars (Europa, Rival, Corsica), which were spring sown in Thessaly, central Greece, for two growing seasons (2003—04). At the beginning of July, sugar beets were subjected to water deficit with irrigation withholding. A month later, three defoliation levels (control — C, moderate — MD, severe — SD) and irrigation were applied. Thus, sugar beets were forced to re-grow and three harvests (15, 30 and 40 days after defoliation — DAD) were conducted. Rotted roots per hectare were counted and pathogens were identified. Data were analyzed as a four-factor randomized complete block design with years, defoliation levels, sampling times and cultivars as main factors. The number of rotted roots was increased with the defoliation level and was significantly higher for SD sugar beets (3748 roots ha^{-1}). No significant differences were found between C and MD treatments (1543 and 2116 roots ha^{-1}, respectively). Rival was the most susceptible cultivar to root rots. Sugar beets were more susceptible to rotting 15 and 40 DAD (2778 and 2998 roots ha^{-1}). The causal agents of root rots were the fungi, *Fusarium* spp., *Rhizopus stolonifer*, *Macrophomina phaseolina* and *Rhizoctonia solani*.

KEY WORDS: defoliation, re-growth, root rot diseases, sugar beet

INTRODUCTION

Sugar beet is the main cash crop for central and northern Greece. In Thessaly plains, sugar beet crop covers the acreage of 10.000 ha. In Thessaly, sugar beet crop productivity is limited by water stress. Drought will become a

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* The paper was presented at the first scientific meeting IV INTERNATIONAL SYMPOSIUM ON SUGAR BEET Protection held from 26—28 september 2005 in Novi Sad.

serious restrictive factor of sugar beet growth in numerous areas in Europe (Jones et al., 2003). In Greece, water deficit occurs in July and August when evapo-transpiration exceeds water inputs. Supplementary irrigation is provided in order to bridge the gap between needs and input but this is often inevitable due to shortage of irrigating water.

Sudden and erratic rainfalls or restoration of irrigation water supply enforce sugar beets to re-grow with detrimental effects on qualitative and quantitative traits of sugar beet roots (Muro et al., 1998). From field observations, sugar beets defoliated by water stress, which are then forced to re-grow show an increasing susceptibility to root rotting after water supply restoration. Thus, the aim of this work was to study the effects and to identify the soil pathogens responsible for root rots which appear after irrigation restoration in three cultivars of sugar beet subjected to drought stress.

METHODS AND MATERIALS

Three sugar beet cultivars (Europa-van der Have, Rilland, The Netherlands, Rival-SES EUROPE NV/SA, Tienen, Belgium, Corsica-Maribo, Danisco Seed, Holefy, Denmark) were established in a randomized complete block design, with four replications, in Amfithea farm of Hellenic Sugar Industry SA (39° 43' N, 22° 28' E, 76 m). Seeding was conducted on 17 April 2003 and on 18 March 2004 and seeds were drilled with Hege 80 machine at 45 cm between rows and 8.1 cm on a row. After seedling emergence, plants were thinned by hand. Sugar beets were provided a total of 150 kg N ha^{-1} (as basal and top-dressing), 75 kg P_2O_5 ha^{-1} and 75 kg K_2O ha^{-1}. Full protection against pests and pathogens was supplied by spraying.

In order to be subjected to drought stress, sugar beets were left without irrigation for about a month (during July). Then, three defoliation treatments (control — C, moderate defoliation — MD, severe defoliation — SD) were applied by hand. At MD treatment, half of the foliage was removed while at SD treatment only the meristems left. Then, irrigation (~70 mm) was applied in order to achieve the foliage re-growth. Three samplings (15, 30 and 40 Days after Defoliation — DAD) were taken in order to study quantitative and qualitative sugar beet traits. In each sampling, two rows (7 m long, 6.3 m^2) were harvested by hand and the total and rotted root numbers were determined. Rotted roots were collected and pathogens were isolated using acidified PDA media. The pathogens were examined using a binocular light microscope. Fungal hyphae, fruiting bodies and spores were used for the identification of the parasitic fungi.

The data of rotted roots were subjected to analysis of variance (ANOVA) as a randomized complete block design with four main factors (years, defoliation levels, sampling times, cultivars). For the analysis, MSTAT-C (version 1.41, Crop and Soil Sciences Department, Michigan State University, USA), statistical package was used and results were compared by LSD test.

RESULTS AND DISCUSSION

No significant differences between main factors were found concerning the total root number (data not shown). Table 1 presents ANOVA for rotted root number. Rotted root number was not significantly affected by years and was marginally insignificant (P=0.055) regarding cultivars. Rival proved to be the most susceptible cultivar to root rots (3021 roots ha^{-1}), followed by Corsica (2668 roots ha^{-1}) which had no significant differences comparing to Europa (1719 roots ha^{-1}). However, a significant Year and Cultivar interaction was evident (Table 1). In 2003, Corsica and Rival preoved to be more susceptible to rotting but in 2004, this was evident for Europa and Corsica. It is well established by field observations that sugar beet cultivars show different reaction to root rots caused by soil fungi.

Table 1. Analysis of Variance (ANOVA) of rotted root number. Where df = degrees of freedom, ns = not significant, * = P

Source of variation	df	*F*	Significance
Block	3	3.29	ns
Years (Y)	1	3.91	ns
Defoliation level (D)	2	7.86	**
Y x D	2	4.21	*
Sampling times (S)	2	3.51	*
Y x S	2	5.11	**
D x S	4	1.60	ns
Y x D x S	4	1.34	ns
Cultivar (C)	2	2.95	ns
Y x C	2	10.91	***
D x C	4	1.82	ns
Y x D x C	4	3.06	*
S x C	4	0.26	ns
Y x S x C	4	0.49	ns
D x S x C	8	0.30	ns
Y x D x S x C	8	1.11	ns
CV (%)		134.53	

Defoliation level and sampling times had a significant impact on root rots. Although MD had no effect on root rots compared to C treatment (2116 and 1543 roots ha^{-1}, respectively), SD significantly increased root susceptibility to rots (Figure 1). A possible explanation for this is that SD plants had osmotically accumulated water in their roots after irrigation, without having an active transpiration surface to limit root water content. Increased root water content and availability are factors promoting root susceptibility to rots (A g r i o s, 1988).

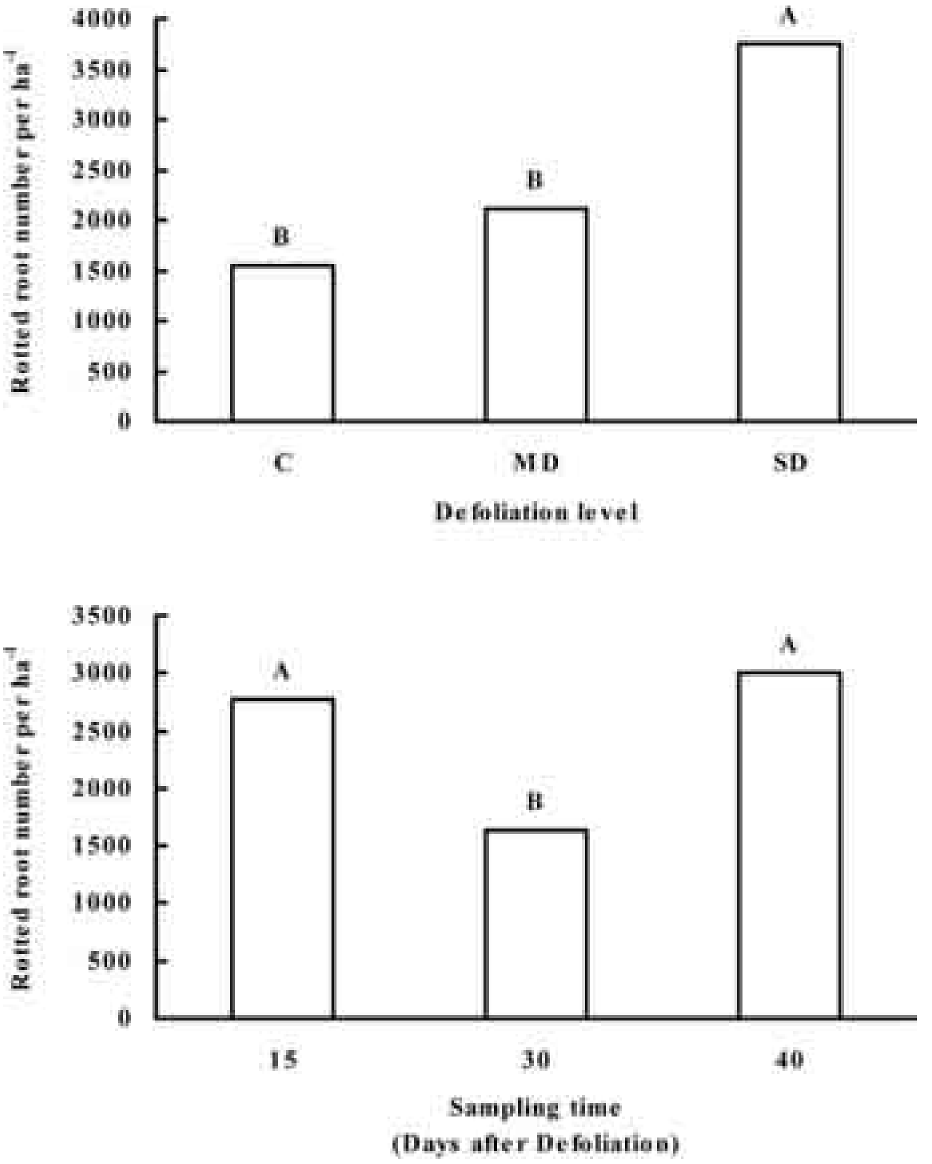

Figure 1. Rotted root number as affected by defoliation level and sampling time

Time of root sampling had a significant effect on rotted root, number being higher at early and late sampling (2778 and 2998 roots ha^{-1}, respectively), while 30 DAD rotted root number was the lowest (1632 roots ha^{-1}) (Figure 1).

Soil fungi identified to cause root rots were *Fusarium* spp., *Rhizopus stolonifer*, *Macrophomina phaseolina* and *Rhizoctonia solani.* All the isolated fungal species correlated with stressed, weakened or injured sugar beets (Hull 1960, Schneider and Whitney, 1986).

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УТИЦАЈ ДЕФОЛИЈАЦИЈЕ ШЕЋЕРНЕ РЕПЕ (*BETA VULGARIS* L.) НА ТРУЛЕЖ КОРЕНА

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Резиме

Циљ овог рада био је да се испита ефекат ретровегетације након опадања лишћа услед водног стреса на трулеж корена три комерцијалне сорте (Еуропа, Ривал, Корсика) које су током пролећа сејане у Тесалији (централна Грчка) током две вегетације (2003—2004). Почетком јула шећерна репа је подвргнута дефициту воде обустављањем наводњавања. Месец дана касније примењена су три нивоа опадања лишћа (контролно, умерено, јако), а наводњавањем прскалицама обезбеђено је око 70 mm воде. Шећерна репа је била присиљена на ретровегетацију. Изведена су и три вађења (15, 30 и 40 дана након опадања лишћа). Избројано је труло корење по ha и идентификовани су патогени. Подаци су анализирани у четворофакторијалном случајном блок-систему са годинама, сортама, нивоима опадања лишћа и вађењем корена као основним факторима. Број трулих корена се повећао са нивоом опадања лишћа и био је значајно већи за шећерну репу са јако опалим лишћем (3748 roots ha^{-1}). Између контроле и умереног опадања лишћа није нађена никаква значајна разлика (1543 и 2116 корена ha^{-1}). Ривал је била најосетљивија сорта (3021 корена ha^{-1}) затим Корсика (2668 корена ha^{-1}) која није имала никакву значајну разлику у односу на Еуропу (1719 корена ha^{-1}). Шећерна репа је била осетљивија на трулеж при вађењу корена 15. и 40. дана након опадања лишћа (2778 и 2998 корена ha^{-1}), док је код 30 дана након опадања лишћа забележен мањи број трулог корена (1632 корена ha^{-1}). Проузроковачи трулежи корена биле су гљиве, *Fusarium* spp., *Rhizopus stolonifer*, *Macrophomina phaseolina* и *Rhizoctonia solani*.

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SURVEY OF ROOT ROT DISEASES OF SUGAR BEET IN CENTRAL GREECE*

ABSTRACT: An extensive survey was conducted during the summer and autumn of 2004 in sugar beet fields in the area of Larissa, Thessaly region, with plants showing symptoms of root rot diseases. The aim of the monitoring was to identify the causal agents of root rot diseases. In total, 76 sugar beet fields were surveyed and 5—10 diseased roots were examined from each field. Isolations, carried out on PDA, showed that two main fungal pathogens causing root rot were *Rhizoctonia solani* and *Phytophthora cryptogea*. The former was isolated in 46% of the fields and the latter in 38% of the fields. In addition, *Rhizopus stolonifer*, *Fusarium* spp., *Scerotium rolfsii* and *Rhizoctonia violacea* were isolated in 14%, 7%, 4% and 1% of the fields, respectively. In most of the surveyed fields only one pathogen species was isolated and only in a few of them more than one fungal species was identified.

KEY WORDS: root rot diseases, sugar beet

INTRODUCTION

During the summer and autumn of 2004, an extensive survey of root rot diseases was conducted in 76 sugar beet fields in the area of Larissa, Thessaly region, where each year 10—12 thousand hectares are cultivated with sugar beet.

The climate in Thessaly is warm and humid with a few rain showers during summer and early autumn. Irrigation is absolutely necessary for sugar beet cultivation. Growers generally use a 3—4-year rotation system mainly with cereals and cotton.

Root rot diseases more often appear in randomly scattered plants within a field, but they also, very often occur in small patches with a few meters in di-

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ameter. It is estimated that an average of 1—5% yield is lost due to these diseases annually, but it is not uncommon to have 10—30% loss in some fields.

Root rot diseases are considered to be of minor importance for the sugar beet crop in Greece and there are only a few reports (G i l p a t h i et al., 2001) related to soil fungal pathogens infecting sugar beet roots. The aim of this survey was to identify the fungal pathogens which relate to this kind of disease symptoms.

MATERIALS AND METHODS

From each sampled field, 5—10 rotted roots were collected and transferred into the laboratory for pathogen isolation. Only roots showing rot in initial stage were selected to reduce contaminating saprophytic microorganisms. Small root tissue pieces, obtained from the margin between the healthy and diseased internal tissue were transferred on PDA slants, amended with lactic acid to avoid bacterial contamination. Petri dishes were incubated in the dark, at 25 C. After 2—3 days of incubation, fungal colonies were visible and agar blocks were removed and transferred to new PDA petri dishes for growth. After a week of incubation, the fungal cultures were identified using a binocular light microscope (magnification 10—40X). Fungal hyphae, fruiting bodies and spores were used for the identification of parasitic fungi.

RESULTS AND DISCUSSION

During summer and early autumn of 2004 the climate in the region of Thessaly was warm and humid. The total amount of precipitation was 32 mm of rainfall. Microscopic examination of the isolated fungal cultures showed that *Rhizoctonia solani* and *Phytophthora cryptogea* are the major soil fungal pathogens of sugar beet roots in Central Greece. They were isolated from all the counties and all the types of soil.

Rhizopus stolonifer and *Fusarium* spp. were isolated only from crops suffering from water deficiency or abnormal irrigation, while *Scerotium rolfsii* was isolated only from fields of saline soil. *Rhizoctonia violacea* was isolated in the field where the previous crop was alfalfa.

In 10 out of 76 sampled fields more than 2 pathogens related to root rot diseases were isolated. Results are shown in Table 1.

The purpose of this paper is to record the fungal pathogens which induce root rot diseases of sugar beet in Central Greece.

The results from the survey showed that *Rhizoctonia solani* and *Phytophthora cryptogea* were the major causal agents of root rot diseases of sugar beets in Thessaly.

Root rot diseases from *Rhizopus stolonifer* and *Fusarium* spp. seem to be related only to sugar beet stressed from draught. *Scerotium rolfsii* and *Rhizoctonia violacea* were only rarely isolated from diseased sugar beet roots. In most cases, only one pathogen was involved in root rot disease in each sampled field.

Table 1. Fungal species isolated from diseased sugar beets showing root rot symptoms in Greece during 2004.

Casual agent	Number of fields with pathogen / Total number of fields	% fields with pathogen
Rhizoctonia solani	35/76	46
Phytophthora cryptogea	29/76	38
Rhizopus stolonifer	11/76	14
Fusarium spp.	5/76	7
Sclerotium rolfsii	3/76	4
Rhizoctonia violacea	1/76	1

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БОЛЕСТИ КОРЕНА ШЕЋЕРНЕ РЕПЕ У ЦЕНТРАЛНОЈ ГРЧКОЈ

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Резиме

Током лета 2004. у пољима шећерне репе у области Ларисе, у региону Солуна, изведен је екстензиван преглед биљака које показују симптоме болести трулежи корена. Циљ мониторинга био је да се идентификују проузроковачи болести трулежи корена. Прегледано је укупно 76 поља шећерне репе и са сваког поља је прегледано 5—10 оболелих корена. Изолације, изведене на ПДА, показале су да су главни проузроковачи трулежи корена два главна патогена изолована из оболелих корена, *Rhizoctonia solani* и *Phytophthora cryptogea*. Први је изолован са 46% поља, а други са 38% поља. Уз то, *Rhizopus stolonifer*, *Fusarium* spp., *Sclerotium rolfsii* и *Rhizoctonia violacea* изоловани су са 14%, 7%, 4% и 1% поља. Код већине прегледаних поља изолована је само једна патогена врста, а само на неколико поља су утврђене више од једне врсте гљива.

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CONTROL OF SUGAR BEET POWDERY MILDEW WITH STROBILURIN FUNGICIDES*

ABSTRACT: *Powdery mildew*, caused by *Erysiphe betae* is a major foliar disease of sugar beet in areas with dry and relatively warm weather conditions throughout the world. In the present study, four fungicides belonging to the relatively new class of strobilurin fungicides, azoxystrobin, kresoxim-methyl, pyraclostrobin and trifloxystrobin were evaluated in three different application doses (100, 150 and 200 mg a.i. ha^{-1}) during 2003—2004 for the control of the disease. Among the four strobilurin fungicides tested, trifloxystrobin and kresoxim-methyl were the most effective with control efficiency values higher than 94% compared to the control treatment even when applied at lower application dose of 100 mg a.i. ha^{-1}. Azoxystrobin and pyraclostrobin showed a poor to modest activity against the disease even when applied at the highest application dose of 200 μg a.i. ha^{-1}. Disease severity, in terms of AUDPC values was significantly correlated to decreased root yield, while no significant correlation existed among disease severity and sugar content of the roots or sucrose yield. In addition, the efficiency of tank mixtures of four strobilurin fungicides applied at 100 μg a.i. ha^{-1} with two sterol demethylation — inhibiting fungicides (DMIs), difenoconazole and cyproconazole applied at 62.5 and 25 mg a.i. ha^{-1}, respectively, was evaluated. The mixtures of azoxystrobin and pyraclostrobin with either difenoconazole or cyproconazole provided a better control efficiency compared to the single application of each mixture partner, while the tank mixtures of trifloxystrobin and kresoxim-methyl with either difenoconazole or cyproconazole provided a better control efficiency compared to single application of difenoconazole or cyproconazole and similar control efficiency compared to the efficiency obtained by single application of the strobilurin fungicides.

KEY WORDS: azoxystrobin, chemical control, *Erysiphe betae*, kresoxim-methyl, pyraclostrobin, trifloxystrobin

INTRODUCTION

Sugar beet powdery mildew, caused by *Erysiphe betae*, is among the most important foliar diseases of sugar beet worldwide. In the conditions of

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high disease pressure and in the absence of control measures, the reduction of root yield may exceed 22% and root sucrose content may exceed 13% (F o r s t e r, 1979). Disease development is favored by dry conditions and relatively high temperatures. The control of disease is mainly achieved by applications of broad spectrum of systemic fungicides, mainly belonging to the ergosterol biosynthesis inhibitors class (EBIs) which are also active against *Cercospora leaf spot* caused by *Cercospora beticola* or by applications of the protective fungicide sulfur which is *powdery mildew* specific (B y f o r d, 1996). Qo inhibiting fungicides (strobilurin and strobilurin-related fungicides) constitute a relatively new fungicide class that inhibits mitochondrial respiration by binding at the Qo site of cytochrome *b*, possessing an extremely broad spectrum of activity against several fungal classes (B a r t l e t t et al., 2002). The current study was conducted to test: i) the efficiency of four strobilurin fungicides, azoxystrobin, trifloxystrobin, pyraclostrobin and kresoxim-methyl against the pathogen in the field conditions and ii) the efficiency of tank mixtures of four strobilurin fungicides with two triazole fungicides, difenoconazole and cyproconazole.

MATERIALS AND METHODS

Fungicides: Fungicides used in the study were commercial formulations of trifloxystrobin (Flint 50 WG), pyraclostrobin (F-500 25), kresoxim-methyl (Strobby 50WG), azoxystrobin (Ortiva 25 SC) difenoconazole (Score 25 EC), cyproconazole (Caddy 10 SL) and sulfur (Thiovit 80 WG).

Plant material: Sugar beet cultivar selected for the experiment was "Rival", a cultivar sensitive to *powdery mildew*. Field plots consisted of six 11-meter rows spaced 45 cm apart and arranged in a randomized block design with four replicates per treatment.

Time of application: Fungicides were applied preventively. Spray applications initiated before the appearance of any disease symptom on the plants, after the "closing" of rows and repeated at intervals of 15—20 days. In total, four spray applications per treatment were carried out. Fungicide solutions were applied using an AZO precision sprayer, at a volume of 0.4 L per plot and pressure 4 atm.

Disease assessment: For the assessment of *powdery mildew* severity, a six-category scale disease index suggested by H i l l s et al. (1980) was used. Scale categories indicated leaf area covered by fungus mycelium (R0 = 0%, R1 = 10%, R2 = 35%, R3 = 65%, R4 = 90%, R5 = 100%). Area Under Disease Progress Curve (AUDPC) was calculated for the assessment period as follows: AUDPC = an i = 1[(Yi + 1 + Yi)/2][ti + 1 -ti] where *Yi* = disease severity at the *i*th observation, *Ti = time (days) at the i*th observation and *n* = total number of observations.

Data on AUDPC values were subjected to an analysis of variance (ANOVA) and compared using the Fischer's least significant difference (LSD) procedure at $p = 0.05$.

RESULTS

Control efficiency of strobilurin fungicides. During both years of the study, AUDPC values in plots treated with fungicides were significantly lower ($P < 0.05$) than in the uintreated control plots. Among four strobilurin fungicides tested, kresoxim-methyl and trifloxystrobin were the most effective. AUDPC values in plots treated with kresoxim-methyl and trifloxystrobin were extremely low in all of three application rates and control efficiency had values higher than 94% during both years of the study. Pyraclostrobin showed a modest activity against *powdery mildew* since AUDPC values in plots treated with that fungicide ranged from 907 to 380 in 2003 and from 910 to 450 in 2004, significantly lower ($P < 0.05$) compared to the respetcie values in plots treated with the same rates of either kresoxim-methyl or trifloxystrobin. Azoxystrobin showed weaker ($P < 0.05$) activity against *powdery mildew* compared to remaining three strobilurin fungicides tested, with AUDPC values ranging from 1585 to 1075 in 2003 and 862 to 698 in 2004. Data on Area Under Disease Progress Curve (AUDPC) are summarized in Table 1. and Table 2.

Table 1. Area under the disease progress curve (AUDPC)[a] of *powdery mildew* on sugar beet and control efficiency (%) in plots treated with strobilurin fungicides in 2003

Treatment	Application Dose gr a.i. ha^{-1}	AUDPC	Control (%)
sulfur	3840	685 f[b]	72.1
azoxystrobin	100	1585 b	35.4
azoxystrobin	150	1300 c	47.0
azoxystrobin	200	1075 d	56.2
pyraclostrobin	100	907 e	63.1
pyraclostrobin	150	525 g	78.6
pyraclostrobin	200	380 h	84.6
kresoxim-methyl	100	125 i	95.0
kresoxim-methyl	150	105 i	95.8
kresoxim-methyl	200	80 i	96.8
trifloxystrobin	100	117 i	95.3
trifloxystrobin	150	85 i	96.6
trifloxystrobin	200	56 i	97.8
control	—	2452 a	—

[a] AUDPC values were calculated according to Wolf and Verreet (2002).
[b] Means followed by different letters in the column are significantly different according to an LSD test at $P = 0.05$.

Table 2. Area under the disease progress curve (AUDPC)[a] of *powdery mildew* on sugar beet and control efficiency (%) in plots treated with strobilurin fungicides in 2004

Treatment	Application Dose gr a.i. ha^{-1}	AUDPC	Control (%)
sulfur	3840	100 g[b]	93.3
azoxystrobin	100	862 c	41.5
azoxystrobin	150	795 d	46.0
azoxystrobin	200	698 e	47.0
pyraclostrobin	100	910 b	38.2
pyraclostrobin	150	469 f	68.2
pyraclostrobin	200	450 f	69.5
kresoxim-methyl	100	42 h	97.0
kresoxim-methyl	150	36 h	97.6
kresoxim-methyl	200	0 i	100
trifloxystrobin	100	91 g	94.0
trifloxystrobin	150	91 g	94.0
trifloxystrobin	200	36 h	97.6
control	—	1471 a	0.00

[a] AUDPC values were calculated according to Wolf and Verreet (2002)
[b] Means followed by different letters in the column are significantly different according to an LSD test at P = 0.05.

Control efficiency of mixtures of strobilurin and triazole fungicides. The trials were designed in order to test the control efficiency obtained by tank mixtures of four strobilurin fungicides used in the study and two DMI fungicides, difenoconazole and cyproconazole. Difenoconazole, applied alone, showed a weak to modest activity against *E. betae* during both years of the study with control efficiency values ranging from 21.1 to 55.7% in 2003 and from 40.3 to 69.9% in 2004, while cyproconazole showed a better performance particularly when applied at the dose of 50 gr a.i ha^{-1}. The addition of the DMI fungicides into the spray solution did not affect the efficacy of trifloxystrobin and kresoxim methyl significantly, since they showed extremely high control efficiency even when they were applied alone at 100 gr a.i ha^{-1}. In contrast, in plots treated with tank mixtures of azoxystrobin or pyraclostrobin and difenoconazole or cyproconazole, disease severity in terms of AUDPC values was significantly lower ($P < 0,05$) compared to that in plots treated with either azoxystrobin, or pyraclostrobin applied at 100 gr a.i ha^{-1} during both 2003 and 2004. Data on Area Under Disease Progress Curve (AUDPC) are summarized in Table 3. and Table 4.

Table 3. Area under the disease progress curve (AUDPC)[a] of *powdery mildew* on sugar beet and control efficiency (%) in plots treated with tank mixtures of strobilurin and DMI fungicides in 2003

Treatment	Application Dose gr a.i. ha^{-1}	AUDPC	Control (%)
sulfur	3.840	420 h[b]	81.9
difenoconazole	62.5	1832 b	21.1
difenoconazole	150	1030 e	55.7
cyproconazole	25	1060 e	54.4
cyproconazole	50	340 h	85.4
azoxystrobin	100	1620 c	30.2
azoxystrobin + difenoconazole	100 + 62.5	1300 d	44.0
azoxystrobin + cyproconazole	100 + 25	890 f	61.7
pyraclostrobin	100	950 ef	59.1
pyraclostrobin + difenoconazole	100 + 62.5	767 g	67.0
pyraclostrobin + cyproconazole	100 + 25	695 g	70.1
kresoxim-methyl	100	80 i	96.6
kresoxim-methyl + difenoconazole	100 + 62.5	40 i	98.3
kresoxim-methyl + cyproconazole	100 + 25	40 i	98.3
trifloxystrobin	100	60 i	97.4
trifloxystrobin + difenoconazole	100 + 62.5	16 i	99.3
trifloxystrobin + cyproconazole	100 + 25	0 i	100
control	—	2320 a	0.00

[a] AUDPC values were calculated according to Wolf and Verreet (2002).
[b] Means followed by different letters in the column are significantly different according to an LSD test at P = 0.05.

Table 4. Area under the disease progress curve (AUDPC) [a] of *powdery mildew* on sugar beet and control efficiency (%) in plots treated with tank mixtures of strobilurin and DMI fungicides in 2004

Treatment	Application Dose gr a.i. ha^{-1}	AUDPC	Control (%)
sulfur	3.840	270 g[b]	84.4
difenoconazole	62.5	102 b	40.3
difenoconazole	150	529 e	69.3
cyproconazole	25	850 c	50.6
cyproconazole	50	170 h	90.1
azoxystrobin	100	952 b	44.7
azoxystrobin + difenoconazole	100 + 62.5	836 c	51.4
azoxystrobin + cyproconazole	100 + 25	650 d	62.3
pyraclostrobin	100	620 d	64.0
pyraclostrobin + difenoconazole	100 + 62.5	480 e	72.1
pyraclostrobin + cyproconazole	100 + 25	350 f	79.7
kresoxim-methyl	100	70 i	96.0

kresoxim-methyl + difenoconazole	100 + 62.5	45 ij	97.4
kresoxim-methyl + cyproconazole	100 + 25	0 j	100
trifloxystrobin	100	65 ij	96.3
trifloxystrobin + difenoconazole	100 + 62.5	10 ij	99.5
trifloxystrobin + cyproconazole	100 + 25	0 j	100
control	—	1720 a	0.0

[a] AUDPC values were calculated according to Wolf and Verreet (2002)
[b] Means followed by different letters in the column are significantly different according to an LSD test at P = 0.05.

CONCLUSIONS

• Significant reduction of *powdery mildew* incidence in all the fungicide-treated plots compared to the untreated control plots.

• Trifloxystrobin and kresoxim-methyl showed better performance compared to remaining two strobilurin fungicides, azoxystrobin and pyraclostrobin that showed a poor to modest activity against the disease, during both years of the study.

• Differences in the level of control efficiency, obtained by several strobilurin fungicide treatments can be explained by variation in the level of intrinsic activity of each fungicide against the pathogen.

• The mixtures of trifloxystrobin or kresoxim-methyl with either difenoconazole or cyproconazole had excellent performance against the disease.

• When cyproconazole or difenoconazole were applied in mixture with azoxystrobin or pyraclostrobin, a significant improvement of control efficiency was achieved compared to the control.

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СУЗБИЈАЊЕ ПЕПЕЛНИЦЕ РЕПЕ СТРОБИЛУРИНСКИМ ФУНГИЦИДИМА

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Резиме

Пепелница коју проузрокује *Erysiphe betae* је у целом свету основна болест лишћа шећерне репе, у подручјима са сувим и релативно топлим временским условима. У садашњем испитивању четири фунгицида који припадају релативно новој класи стобилуринских фунгицида, азоксистробина, кресоксим-метила, пираклостробина и трифлоскистробина, током 2003—2004, у циљу сузбијања ове болести испитане су у три различите количине примене (100, 150 и 200 μg а.и. ha^{-1}). Од четири испитана, трифлокситробин и кресоксим-метил су били најделотворнији у сузбијању са ефикасношћу већом од 94% у поређењу са контролним третманом чак и приликом примене ниже количине од 100 μg а.и. ha^{-1}. Азоксистробин и пираклостробин били су слабо или умерено активни против ове болести чак и приликом примене највише количине од 200 μg а.и. ha^{-1}. Јачина болести, у терминима вредности АУДПЦ, била је у значајној корелацији са смањеним приносом корена, док није постојала значајна корелација између јачине обољења и садржаја шећера корена или приноса шећера. Уз то, испитана је ефикасност мешавина четири стробилуринска фунгицида примењена са 100 μg а.и. ha^{-1} са два стерол деметилацион-инхибирајућим фунгицидима (ДМИс), дифеноконазолом и цирпоконазолом примењенима са 62,5 и 25 μg а.и. ha^{-1}. Мешавине азокситробина и пираклостробина са дифеноконазолом или ципроконазолом обезбедиле су бољу ефикасност у сузбијању у поређењу са појединачним применама сваког фунгицида у мешавини, док су мешавине трифлоксистробина и кресоксим-метила са дифеноконазолом или ципроконазолом показале бољу ефикасност у поређењу са појединачним применама дифеноконазола или ципроконазола и сличну ефикасност у сузбијању у поређењу са оном постигнутом приликом појединачних примена стробилуринских фунгицида.

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RETROSPECTION CONCERNING THE SUGAR BEET PROTECTION ON FUNDULEA ZONE, DISTRICT CALARASI, ROMANIA*

ABSTRACT: The paper represents a synthesis concerning sugar beet protection in the specific conditions (soil and climatic) of Fundulea zone. The presented aspects refer to the beet diseases, pests and weeds (primary and secondary concerning economic importance) since these organisms are continually limiting root and sugar yields. At the same time, it refers to the present control possibilities, the aim being the efficiancy and environmental demands. The basis of the synthesis are main data and results obtained at the Institute (in experimental fields and demonstration plots), during 1982—2003 (the Institute was founded in 1981) about natural infections and infestations without treatments. It contains three parts (pathogens, pests, weeds) and has original pictures enclosed in the annex: some symptoms of pathogen and pests attacks, weed control and other aspects such as herbicides fitotoxity, strangled roots, *Cuscuta* as a parasitic plant etc.

KEY WORDS: control, diseases, fungicides, herbicides, insecticides, pests, sugar beet, weeds

DISEASES

Primary and secondary beet diseases are shown in Table 1. The mean values (frequency F %, attack degree AD %) were dependent on weather conditions favorability (air temperature, air and soil humidity, seed infections with some pathogens such as *Phoma*, *Peronospora*, *Cercospora*, this having the values of 26—34% to 61% (the seed having untreated lots as source).

For Fundulea conditions, the main diseases were fungal: *Cercospora leaf spot* (29% AD, with 63,9% as maximum in 1997), *black leg* (21,5% F, with 31,8% as maximum in 1997), *powdery mildew* (19,1% AD, with 33,4% as maximum in 1996), incipient infections of *downy mildew* (9,8% F, with 29,8% as maximum in 1989), the other fungal and bacterial leaf diseases registering under 10% of attack frequency. However, during 1990—1993, there were

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many bacterial lesions on petioles of leaves and *downy mildew* frequency up to 53% in the second half of summer. Concerning virus diseases (*yellows*, *mosaic*), their attack frequency was 21,1%, 20,4%, respectively, generally the values decreasing in the period analyzed (which is in correlation with the vectors decline). *Rhizomania* was not present in Fundulea zone, but it remains one of the major diseases for other districts.

Regarding the root rots, these registered low values as frequency attack was (under 5%) 1,5% for soft rot and 4,5% for fungal roots (dominant pathogens being *Fusarium*, *Pythium* and *Phoma*; in the conditions of the year 1998, there was a sporadical attack of *Phytophtora megasperma — wet rot*).

Beet diseases caused 30—40%, mean damages of yield varieties potential.

Preventive measures as technological elements (rotation of crops, fertilizing, tolerant varieties, seed treatment, etc.) enabled only a limited protection of beet plants. Therefore, curative measures were necessary (the fungicides used proved efficiancy ensuring the environmental demands as well, being of low toxity group). Some of the fungicides and antibiotics used for seed treatment and foliar treatment are shown in tables 2 and 3. The treatments assured good efficiancy (87—92%) for diseases of the following period (*black leg*, *downy mildew*) and 90—98% at foliar diseases. The fungicides applied for the main foliar disease control, *Cercospora leaf spot* (with contact and systemic action) were used as elements of F.R.A.C. strategy (Fungicide Resistance Action Committee), the aim being the prevention of pathogen resistance (in the south of the country this has already been installed with fungicides of benzimidazole and carbonic acid chemical group). The interval between foliar treatments was 8—12 days for contact fungicides and 18—21 days for systemic fungicides, depending on the infection pressure caused by weather conditions favorability. At the first symptoms of disease we applied the first treatment (not later). In Fundulea, 3, rarely 4 treatments were necessary.

In some years, the holoparasitic plant *Cuscuta* spp. was present on beet plants which remained small and yellow.

Concerning *Cercospora leaf spot* control, the fungicides based on stanium acetate or hydroxide were replaced (with clorotalonil) because of environmental demands.

PESTS

In Fundulea, the beet crops are attacked by about 20 pests. Some of them are very important by their high density and especially in favorable conditions for attack. Pests, especially soil pests can destroy the crop. In this zone soil pests like *weevils* (*Bothynoderes punctiventris*, *Tanymecus* spp.), *wireworms* (*Agriotes* spp.), *beet flea* (*Chaetocnema* spp.) are very important. Their cumulative attack destroyed over 50% of plants and in some areas even more than that. In dry years (2002, 2003), *weevils* and *beet flea* attack was very intense (85% was frequency attack of *Bothynoderes* and 100% for *Chaetocnema*), but in cold and rainy spring of 1997, *Agriotes* density was high (up to 4 *wire-*

worms per young plant and after lucerne, as precursory plant, more than 4; in this case the crop was destroyed).

We used different insecticides for seed treatment (table 4 has an example for year 1997) and the efficiancy was (mean values) more than 97% for *Agriotes* control, between 89—94% for *Chaetocnema* control and 83—88% for *Bothynoderes* control (these products replaced the old products like Lindatox, Duplitox, Heptaclor, Sinoratox, then Furadan). Because of high density of *weevils* (more than 7 insects/sq. m.) and of *beet flea*, foliar treatments were applied (complementary to seed treatment) using insecticides such as Karate Zeon, Polytrin 200 EC, Regent 200 SC.

Other pests were: *black aphid* (*Aphis fabae*), *peach aphid* (*Myzus persicae*), *rot aphid* (*Pemphigus fuscicornis* as *Aphididae*); also, *Lepidoptera* as *beet moth* (*Scrobipalpa ocellatella*), *tiger moth* (*Hyphantria cunea*), *cutworms* (*Agrotis segetum*), *leaf-eaters* (*Mamestra brassicae*, *Plusia gamma*); concerning *beet leaf miner* (*Pegomia betae*) and *beet cyst-nematode*, their attack was sporadical. However, as a particular aspect, we mention the attack of *rot aphid Pemphigus* (very virulent in 2000 and 2001, when about 15%, 18% of the plants were affected, respectively), *beet flea* attack (to 100% plants with holes, especially in the last years) and in some years *Lixus junci* attack (the larvae caused 7—16% broken petioles).

The mean yield damages caused by foliar pests were more at sugar (50—60%).

For the control of foliar pests different products were used (some of them in table 5), their efficiancy being more than 95%. These replaced the insecticides of the first and secondary toxity groups. The treatments were applied at warning for *Aphididae* (usually when the first colonies come out) and also at warning for *Lepidoptera*, the warning in this case being based on "feromonal traps" using synthetical feromons (4 traps/ha).

Not only chemical control for *Lepidoptera* was used. Their biological control was accomplished with *Trichogramma wasp* spp. (1986—1998) having the same efficiancy with the "piretroid" insecticides (we used about 150.000 eggs parasited with *Trichogramma*/ha/treatment), 2—3 treatments were applied.

As biological products, Muscardin 45m (based on *Bauveria* fungus) for *Bothynoderes* and *Tanymecus* limitation and Thuringing 150 M (based on *Bacillus thuringiensis bacterium*) for *Plusia*, *Agrotis* and *Mamestra* limitation were used. The biological products also protected the auxiliary useful entomofauna like the invertebrate groups (*Oribatidae*, *Collembolae*, *Enchytreide*) and *Harpalus aeneus*, *Calosoma* spp., *Coccinellidae*, *Arachnidae*.

WEEDS

In the Fundulea conditions beet crops were infested with many weeds (more than 150 annual and perennial, monocotyledonous and dicotyledonous species). About 40 species were more frequent, constituting a serious problem because they compete with beet plants and at the same time are "host plants" for pathogens and pests. Generally, infestations were high and very high (180—210 to 400—550 weeds/sq. m. in some areas). Frequent weed species were *Cirsium arvense*, *Convolvus arvensis*, *Sonchus arvensis*, *Cardaria draba*, *Sorghum halepense*, *Agropyron repens*, *Cynodon dactylon* as perennial; *Setaria* spp., *Digitaria sanguinalis*, *Echinochloa crus-galli*, *Poa anua*, *Avena fatua*, *Alopecurus myosuroides*, *Agrostis tenuis*, *Apera spica-venti*, *Amaranthus retroflexus*, *Atriplex patula*, *Capsella bursa-pastoris*, *Chenopodium album*, *Fumaria officinalis*, *Galium aparine*, *Polygonum aviculare*, *Matricaria chamomilla*, *Raphanus raphanistrum*, *Senecio vernalis*, *Sinapis arvensis*, *Solanum nigrum*, *Stellaria media*, *Thlaspi arvense*, *Portulaca oleracea*, *Viola tricolor*, *Xanthium strumarium*, *Polygonum convolvulus*, *Mercurialis annua*, *Polygonum persicaria*, *Galeopsis tetrahit*, *Taraxacum officinale*, *Abutilon theophrasti* as annual weeds.

However, among weeds, great damage was caused by "problem weeds" such as *Cirsium arvense*, *Convolvulus arvensis*, *Sorghum halepense*, *Agropyron repens*, *Cynodon dactylon*, *Arena fatua*, *Solanum nigrum*, *Apera spica-venti*, *Echinochloa crus-galli*, *Polygonum convolvulus*, *Xanthium strumarium*.

At big infestations, the loss of sugar yield was 60—65%. The preventive measures were not enough, thus the chemical control was also necessary.

Because of high infestation, two kinds of applications were necessary (one in pre-emergence period and 2—3 in post-emergence period). All herbicides used were selective (note 1 on EWRS scale) for beet plants (table 6). At pre-emergence period, in the last years, we used the mixture Frontier + Pyramin (Cerberus) for annual monocotyledonous and dicotyledonous control. At post-emergence period, for annual dicotyledonous, broad spectrum of herbicides with improved effect was necessary (constituted on 3 active ingredients as Regio or Betanal expert) applied in 2—3 treatments. Regio, as active ingredients has 50 g/l fenmedifam + 50 g/l desmedifam + 300 g/l cloridazon and Betanal expert has 91 g/l fenmedifam + 71 g/l desmedifam + 112 g/l etofumesat. The interval between treatments is of 7—11 days, the treatments being applied when weeds are sensitive (cotyledons stage for Betanal up to 2 and no more than 4 leaves for Regio). For monocotyledonous control, one of these herbicides was mixed with Aramo 50 when perennial weeds had 10—15 cm (*Agropyron*) and 15—20 cm (*Sorghum*).

Cirsium arvense was controlled using herbicides based on "clopiralid" (10—12 cm rosette stage, no more than 15 cm).

Perennial weeds were controlled with 1—2 treatments.

The whole system (pre-emergence + post-emergence) determined 80—95% as control degree, this depending on the infestation degree, the structure and domination of species, the size of the weeds and weather conditions.

The increase of *Cirsium arvense* and *Abutilon theophrasti* infestation in the last 5 years (on some portions in some areas to 92, 11 plants/sqm, respectively) should be mentioned as well as *Convolvulus arvensis* for its difficult control (though it can be controlled using Roundup Ready herbicide on "RR" varieties or Liberty herbicide on varieties showing resistance to this herbicide; tested in the 1998—2000 period).

CONCLUSIONS

1. The main diseases are: *black leg*, *Cercospora leaf spot*, *powdery mildew*, *downy mildew*, virus diseases and in some years *Alternaria leaf spot* and *Bacterial leaf spot*. *Rhizomania* is not present in Fundulea.

2. The main pests are: *weevils*, *beet flea*, *wireworms*, then *Lepidoptera*, *Root aphid Pemphigus* and other *Aphididae*; in some years *Lixus* spp. as well.

3. In the conditions of Fundulea the weeds were much present (broad spectrum of species). The total control of them could be possible using only genetically modified varieties.

4. For diseases and pests control (preventive measures enabled only a limited protection) chemical treatments were necessary, taking into account the environmental demands and resistance warning. Having this in mind, we promoted chemical products of low toxity, biological and antibiotic products.

Table 1. The Diseases Attack on Sugar Beet Crop in Fundulea (F % — frequency of attack; A.D. % — attack degree)

Diseases (Pathogens)	Mean Values						Mean
	1982—1985	1986—1989	1990—1993	1994—1997	1998—2001	2002—2003	
Black leg — F % (*Pythium* spp., *Phoma betae, Fusarium* spp., *Aphanomyces cochlioides, Rhizoctonia solani*)	23,3	24,0	19,5	27,3	17,9	16,8	21,5
Incipient infections of Downy mildew — F % (*Peronospora farinosa*)	12,2	19,6	14,0	6,8	3,3	3,1	9,8
Cercospora leaf spot — A.D. % (*Cercospora beticola*)	30,0	28,1	37,3	49,2	16,8	15,9	29,6
Powdery mildew — A.D. % (*Erysiphae betae*)	20,8	25,5	18,6	28,9	8,6	12,0	19,1
Alternaria leaf spot — F % (*Alternaria tenuis*)	9,6	8,1	10,0	5,9	6,8	4,7	7,5
Downy mildew — F % (*Peronospora farinosa*)	8,6	7,2	8,5	9,7	5,0	6,1	7,5
Phoma leaf spot — F % (*Phoma betae*)	5,8	7,9	7,1	9,4	3,2	5,9	6,6
Ramularia leaf spot — F % (*Ramularia beticola*)	9,6	4,0	5,4	8,4	3,2	6,2	6,1
Rust — F % (*Uromyces betae*)	6,1	3,9	4,1	4,7	2,8	3,0	4,1
Bacterial leaf spot — F % (*Pseudomonas aptata*)	4,5	5,5	16,4	3,8	4,0	8,9	7,2
Crown gall — F % (*Agrobacterium tumefaciens*)	3,5	4,2	3,8	5,1	—	—	2,8
Xanthomonas gall — F % (*Xanthomonas beticola*)	2,7	—	1,4	2,6	—	—	1,1
Soft rot — F % (*Erwinia carotovora*)	1,2	—	3,7	1,4	—	—	1,2
Fungal root rots — F % (*Fusarium* spp., *Pythium* spp., *Phoma betae, Rhizoctonia violacea, Phytophtora* spp.)	7,1	4,3	5,1	2,7	3,8	6,0	4,8
Virus yellows — F % (*Beet yellows virus*)	27,1	29,4	31,5	10,4	19,1	8,9	21,1
Mosaic — F % (*Beet mosaic virus*)	25,5	23,0	27,2	20,0	16,3	10,4	20,4

Table 2. Fungicides Used for the Beet Seeds Treatment

Product (active ingredient; kg/t. seed)	Control					
	Fusarium spp.	*Pythium* spp.	*Phoma betae*	*Rhizoctonia solani*	*Aphanomyces cochlioides*	*Peronospora farinosa*
Tiradin 500 SC (500 g/l tiram; 10)	♦	♦	♦			
Tiramet 60 PTS (40% tiram + 20% tiofanat metil; 5)	♦	♦	♦	♦		
Tachigaren 70 WP (70% himexazol; 6)	♦	♦	♦	♦	♦	
Apron XL 350 ES (350 g/l metalaxil; 4)		♦				♦
Previcur 607 SL + Tiradin 70 PUS (607 g/l propamocarb + 70% tiram; 20 + 6)	♦	♦	♦		♦	♦
Validacin 3 S (3% validamicin; 3)		♦	♦	♦		

Table 3. Fungicides Used for the Control of Main Foliar Beet Diseases

Product (kg/ha/treatment)	Cercospora leaf spot	Powdery mildew	Downy mildew
Score 250 EC (0,3)	♦	♦	
Rias 300 EC (0,3)	♦	♦	
Tilt 250 EC (0,3)		♦	
Alto combi 420 SC (0,5)	♦	♦	
Alert (0,5)	♦	♦	
Tango super (1,0)	♦	♦	
Impact 250 SC (0,250)	♦	♦	
Kasumin 2 L (2)	♦		
Bravo 500 SC (2)	♦		
Thiovit jet (5)		♦	
Funguran OH (4)			♦

Table 4. Insecticides Used for the Control of the Main Soil Pests (frequency of attack)

Product (dose)	*Bothynoderes punctiventris*	*Tanymecus dillaticolis*	*Chaectonema tibialis*	*Agriotes* spp.
Montur 190 FS (19 g a.i./u.g.)	11,3	6,4	7,2	0,5
Gaucho 70 WP (30 g/kg)	10,4	9,7	6,4	0,4
Mospilan 70 WP (30 g/kg)	11,7	8,3	9,3	0,7
Cosmos 250 FS (15 ml/kg)	14,5	11,2	11,3	1,2
Cruiser 350 FS (20 ml/kg)	12,4	10,3	9,47	0,9
Untreated	85	72,1	100,0	100,0

Table 5. Insecticides Used for Foliar Pests Control

Product	Dose (l/ha/treatment)	Pest (homologated tests)
Alpha combi 26,25	0,6	*Lepidoptera*
Fastac 10 CE	0,1	*Lepidoptera, Beet flea*
Karate Zeon	0,2	*Weevils, Lepidoptera*
Polytrin 200 EC	0,1	*Weevils, Beet flea, Lepidoptera, Aphididae*
Chinmix 5 EC	0,3	*Lepidoptera, Aphididae*
Regent 200 SC	0,1	*Weevils*
Sumi alpha 2,5 EC	0,3	*Lepidoptera*
Talstar 10 EC	0,1	*Lepidoptera*

Table 6. Herbicides Used for Weeds Control at Sugar Beet Crop

Product	Dose (l/kg/treatment)	Weeds controlled
Agil 100 EC	1—2 (post-emergence)	*Monocotyledonous*
Aramo 50	1—2 (post-emergence)	*Monocotyledonous*
Betanal expert	1,2 (post-emergence)	*Annual dicotyledonous*
Cliophar 300 SL	0,5 (post-emergence)	*Cirsium arvense*
Frontier 900 EC	1—1,2 (pre-emergence)	*Annual monocotyledonous*
Fusilade super	2—3 (post-emergence)	*Monocotyledonous*
Gallant super	1—1,5 (post-emergence)	*Monocotyledonous*
Kerb 50 W	4 (post-emergence)	*Cuscuta* spp.
Pyramin Fl	6—9 (pre-emergence)	*Annual dicotyledonous*
Regio	3 (post-emergence)	*Annual dicotyledonous*
Pantera 40 EC	0,75—1,5 (post-emergence)	*Monocotyledonous*
Leopard 5 EC	0.75—1,5 (post-emergence)	*Monocotyledonous*

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ИСТОРИЈАТ ЗАШТИТЕ ШЕЋЕРНЕ РЕПЕ У ОБЛАСТИ ФУНДУЛЕА, КАЛАРАСИ, РУМУНИЈА

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Резиме

Овај рад је синтеза у односу на заштиту шећерне репе у специфичним земљишним и климатским условима области Фундулеа. Представљени аспекти односе се на обољења, штеточине и корове (основне и секундарне економске важности). Ови организми ограничавају принос корена и шећера, али у исто време представљају могућности за сузбијање, чији је циљ ефикасност у складу са захтевима животне околине. Синтеза има основну базу података и резултате добијене у експерименталним пољима и демонстрационим парцелама Института, током 1982—2003 (Институт је основан 1981) о природним заразама и нападима инсеката без третмана. Састоји се из три дела (патогени, штеточине, корови), а у додатку садржи оригиналне слике неких симптома напада патогена и штеточина, сузбијања корова и других аспеката као што су то фитотоксичност хербицида, *Cuscuta* итд.

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POTENTIAL AND REAL RESIDUES OF PESTICIDES IN SUGAR BEET*

ABSTRACT: Crops and their products can be contaminated either by direct application of pesticides for the protection of insects, acarives, agents of plant diseases and/or weeds, i.e. as the result of growing them on the soil containing pesticide residues applied in previous years.

For the protection of sugar beet in our country, 23 insectisides, 17 fungicides and 18 herbicides have been registered. The pre-harvest interval (PHI) ranges from 14 to 42 days, i.e. they are provided by the time of application (PTA) whereas the pre-harvest interval for herbicides ranges from 30 to 91 days and is ensured by the application period.

Based on the results from the literature and on their own studies, the authors are of the opinion that the residues of the applied pesticides in sugar beet protection in accordance with the principles of good agricultural practice will be significantly lower than the maximum tolerable ammounts and that at the level from 1/4 to 1/10 of MRL.

IT is necessary to emphasize the necessity of MRL determination both in leaves and in sugar loaf.in case they are used as animal feed.

KEY WORDS: sugar beet, pesticides, residues, MRL (maximum residue level), pre-harvest interval (PHI)

INTRODUCTION

Crops and their products can be contaminated either by direct application of pesticides, acarives, agents of plant diseases and/or weeds, i.e. as the result of growing them on the soil containing pesticide residues applied in previous years. Sugar beet demands intensive protection during vegetation and for that purpose for the protection of sugar beet in our country 23 insecticides, 17 fungicides and 18 herbicides have been registered as active ingredients or their combinations (M i t i ć, 2004, S a v č i ć - P e t r i ć, 2005) (Table 1). The majority of the registered insecticides are non-systematic in contrast to a greater

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part of fungicides that are systematic in action. Chemically, they belong to various groups. Among insecticides, the dominant ones are synthetic pirethroides and organophosphate compounds, among fungicides triazolinones and among herbicides aril-oxycarbon acids.

Table 1. Pesticides Registered for in Sugar Beet

Insekticide (active ingredians)	MRL (mg/kg)	PHI (days)
bifenthrin	0,01	21
lambda-cyhalothrin	0,01	14
tefluthrin	0,02	PTA
alpha-cypermethrin	0,05	35
cypermethrin	0,05	35
esfenvalerat	0,05	14
fenthion	0,05	42
hlorpyrifos	0,05	28
methidathion	0,05	21 r; 42 l
monocrotophos	0,05	42
phoxim	0,05	35
imidacloprid	0,05	PTA
terbufos	0,05	PTA
dimethoate	0,1	42
endosulfan	0,1	35
fenitrothion	0,1	42
carbofuran	0,1	PTA
carbosulfan	0,1	PTA
methomyl	0,1	42
oxydemeton-methyl	0,1	42
malathion	0,5	35
pyrimiphos-methyl	0,5	28
thyametoxam	/	PMA
cyproconazole	0,02	42
flutriafol	0,02	35
chlorothalonil	0,05	21
difenoconazole	0,05	14 l; 35 k
epoxikonazole	0,05	42
flucvinconazole	0,05	PTA
flusilazole	0,05	21
propikonazol	0,05	
benomyl	0,1	42
carbendazim	0,1	42
fentin-hydroxide	0,1	28 r; 42 l
tetraconazole	0,5	21
triforine	0,5	42
carboxin	/	PMA
mancozeb	/	PMA
thiram	/	PMA

MRL — maximum residue level; PHI — pre-harvest interval; PTA — provided by the time of application; PMA — provided by the application mode; r — root; l — leaves.

Applied insecticides are neuroactive compounds: orgahochlorine insecticides and synthetic pirethroides interfere with axonal transmission, organophosphate and methyl-carbamate insecticides inhibit the activity of acetylcholine--esterase and neonicotinoides bind to acetilholine receptor.

Regarding the fungicide action, triazoles are ergosterol biosynthesis inhibitors, ditiocarbamates inhibit the respiration, inactivating — SH groups in enzymes of pathogens, benzimidazoles inhibit cell division (β tubuline synthesis) and DNA biosynthesis, while organotin compounds inhibit the oxidative phosphorylation.

Herbicides act as the inhibitors of photosynthesis (elctron transport), biosynthesis of lipides, cell division etc.

RESULTS AND DISCUSSION

Residues of fentin acetate (1966—1968) and fentin hydroxide (1967—1969) were determined in leaves with loafs and roots without sugar beet loafs treated by pesticides Brestan (20% of fentin acetate), Duter (20% of fentin hydroxide) and Liro (34% of maneb and 11.5% of fentin acetate) in different concentrations, localities and application techniques (Š o v l j a n s k i, 1970, 1971).

After a 42-day interval, a root without loaf can be used for obtaining sugar, molasses and pulp for stock feeding. Fungicide residues were 0.03—0.08 mg/kg (MRL amounts 0.10 mg/kg).

Fentin acetate residues in leaves with head that were found 42 days after treatment were 0.3—0.65 mg/kg. Three weeks after the second treatment, fentin acetate residues in sugar beet leaves represented 2/3 of tolerant value and 6 weeks after treatment about ¼ of tolerant value.

Due to the fact that treated leaves of sugar beet leave a specific smell and taste in the milk of dairy cows fed by it, they are not used as the only animal feed, thus reducing the possibility of contamination by these compounds. The existing pre-harvest interval, i.e. time of waiting of 42 days is completely safe.

During 1984 and 1985, 41 samples of sugar beet roots and sugar from all Slovakian sugar plants were analyzed. The content of some herbicides such as fenmedipham, desmedipham, lenacil and chloridazon in sugar beet root was 0.001—0.1 mg/kg, while in sugar it was under the detection limit (0.001 mg/kg) (T e k e l et al., 1988).

The literature overview of pesticide residues in sugar beet leaves and roots, published in FAO in the period 1993—2000 is given in Table 2.

Table 2. Residues Pesticide in Sugar Beet Root and Leaves in Control Conditions

Insecticide active ingredians	MRL (mg/kg)	PHI (days)	Country	Year	Aplication rate (kg a.i./ha)	Days after treatments	Residues mg/kg		References
							leaves	root	
dimethoate	0,1	42	UK	1996	0,40	/	/	< 0,01	FAO, 1998
dimethoate			Denmark	1996	0,40	/	/	< 0,02	FAO, 1998
dimethoate			Germany	1996	0,16	35	/	< 0,05	FAO, 1998
chlorpyrifos	0,05	28	Canada	1997	1,2	90	/	< 0,01	FAO, 2000
chlorpyrifos			France	1997	1,5	/	/	< 0,01	FAO, 2000
chlorpyrifos			USA	1997	1,1	30	/	0,01—0,03	FAO, 2000
carbosulfan	0,1	PTA	Spain	1993	0,6—1	79—120	/	< 0,05	FAO, 1993
carbofuran	0,1	PTA	USA (Idaho)	1992	2,24	86	0,05	/	FAO, 1997
carbofuran			USA (Oregon)	1991	2,24	92	< 0,01	< 0,01	FAO, 1997
carbofuran			USA (Idaho)	1991	2,24	173	< 0,01	< 0,01	FAO, 1997
carbofuran			USA (Wyoming)	1991	2,24	181	< 0,01	< 0,01	FAO, 1997
						0	1,9		
oxydemeton-methyl	0,1	42	France	1991	0,38	29	< 0,04		FAO, 1998
						0—61		< 0,04	
						0 L	0,80		
oxydemeton-methyl			France	1991	0,38	29—61	< 0,04		FAO, 1998
						0—61		< 0,04	
						0—14	3,0—0,08		
oxydemeton-methyl			Germany	1991	0,2	28—35	< 0,04		FAO, 1998
						0—35		< 0,04	
						0—14	1,9—0,09		
oxydemeton-methyl			Germany	1990	0,19	28—35	< 0,04		FAO, 1998
						0—35		< 0,04	

MRL — maximum residue level; PHI — pre-harvest interval; PTA — provided by the application period.

Among fungicides that are registered for use in sugar beet protection, only some triazoles have determined pre-harvest intervals and MRL separately for leaves and roots, unlike other chemical compounds (Table 3).

Table 3. Some fungicides pre-harvest interval and MRL for sugar beet leaves and root

Fugicides	Leaves		Root	
	PHI days	MRL mg/kg	PHI days	MRL mg/kg
Difenoconazole	14	0.05	35	0.05
Propiconazole	14	0.05	35	0.05
Tetraconazole	21	0.5	21	0.1

PHI = pre-harvest interval; MRL = maximum residue level

In 1981 FAO anticipated guideline levels as a proposal for MRL for benomyl and carbendazim in sugar beet root in the quantity of 0.5 mg/kg and in leaves 5.0 mg/kg.

In the paper the pre-harvest intervals and MRL for pesticides registered in our country are given as well as detected pesticide residues in sugar beet roots and leaves from trials performed in controlled conditions. Respecting the principles of good agricultural practice, referring to the use of approved chemical compounds only in determined rate/concentration, in defined manner, phenophase etc. and with respect to the pre-harvest interval, it can reliably be said that the use of pesticides for sugar beet protection is entirely safe regarding the sugar beet root processing into sugar, molasses and pulp. Pesticide residues during sugar beet root extraction and processing represent usually about ¼ or 1/10 MRL.

If leaves with head are intended for animal feed, pre-harvest intervals for leaves must be determined as well as MRL for the pesticides that are used in sugar beet protection.

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ПОТЕНЦИЈАЛНИ И РЕАЛНИ ОСТАЦИ ПЕСТИЦИДА У ШЕЋЕРНОЈ РЕПИ

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Резиме

Пољопривредни усеви и њихови производи могу бити контаминирани било услед директне примене пестицида у циљу заштите од штетних инсеката, прегљева, проузроковача биљних болести и/или нежељених корова, односно услед гајења на земљишту које садржи остатке пестицида примењених ранијих година.

За заштиту шећерне репе у нашој земљи регистровано је 23 инсектицида, 17 фунгицида и 18 хербицида. Каренце за инсектициде и фунгициде се крећу од 14 до 42 дана, односно одређене су временом примене (ОВП), док се каренце за хербициде крећу од 30 до 91 дан, односно обезбеђене су временом примене.

Прегледом резултата одређивања из литературе и сопствених истраживања, аутори сматрају да ће остаци примењених пестицида у заштити шећерне репе, уз поштовање принципа добре пољопривредне праксе, бити знатно испод максимално дозвољених количина (МДК) и то на нивоу 1/4 до 1/10 од МДК.

Треба нагласити неопходност одређивања МДК за пестициде и у лишћу и на глави шећерне репе, уколико се они користе као сточна храна.

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HIGH RISK PESTICIDES IN SUGAR BEET PROTECTION*

ABSTRACT: According to traits of pesticides permitted to use in sugar beet (oral, percutaneus and inhalation toxicity, toxicity to wildlife, bees and aquatic organisms, re-entry interval, maximum number of treatments, effects on reproduction) do not present health risk in sugar production/technology. However, the danger exists for workers by chronic exposure during the application, especially from pesticide being potential endocrine disruptors (EDS) (fentin acetate, benomyl, endosulfan, methomyl, methidathion). EDS can cause sterility or decreased fertility, impaired development, birth defects of the reproductive tract and metabolic disorders. Authors recommend limited application of EDS pesticides (to limit the number of treatments to only one during the vegetation), replacement with pesticides with low risk to humans, game and fishes, as well as mandatory submission of re-entry data for registration

KEY WORDS: insecticides, fungicides, sugar beet, toxicity, EDS

INTRODUCTION

Sugar beet is one of five most important crops in Vojvodina region. The production technology requires most intensive control of great number of pests, pathogens and weeds. For this purpose, in Serbia, permission to be used in sugar beet are granted 23 insecticides and acaricides, 17 fungicides and 18 herbicides, altogether 57 active ingredients and their combinations (Savčić, Petrić, 2005).

Already in 1988, sugar beet was heavily protected. Consumption of sugar beet pesticides in Vojvodina in 1988 was 26,8 kg/ha (61,7% insecticides, 6,1% fungicides and 32,4% herbicides (Marković, 1988). At that time, 10 fungicidal active ingredients (against *Cercospora beticola* and powdery mildew)

* The paper was presented at the first scientific meeting IV INTERNATIONAL SYMPOSIUM ON SUGAR BEET Protection held from 26—28 september 2005 in Novi Sad.

and 19 insecticide and 16 herbicide active ingredients were permitted. According to data of Regional Office for Agriculture of Province of Vojvodina, agriculture inspection services, pesticides distributors and big agricultural estates, the consumption of pesticides in sugar beet was 17,8—47,2 kg/ha with an average of 3—12 treatments per season (Š o v l j a n s k i, 1987).

ANALYSES OF DATA PRESENTED IN HANDBOOK ON PESTICIDES REGISTERED IN SMN

For each registered pesticide permitted for sugar beet protection in mentioned Handbook (M i t i ć, 2004), the following data are cited: acute oral medium lethal dose (AOLD50) and acute dermal medium lethal dose (ADLD50), acute inhalation medium lethal concentration (AILC50), toxicity for rats; genotoxicity (mutagenicity, teratogenicity, carcinogenicity and effects on reproduction); eco-toxicological data (toxicity for aquatic organisms — two species of fish, daphnia and algae, honey bees, birds, (MRL) maximum residual limits), (PHI) pre-harvest interval and not always — REI (re-entry interval), data on application-dosage/concentrations, timings of treatment, number of treatments in one vegetative season), data on application from aircraft and buffer zone to waterways and settlements; phytotoxicity, compatibility, mechanisms of action, signs of poisoning and first aid (Table 1. and 2).

Table 1. Toxicological traits of insecticides registered for sugar beet

Insecticides	for rats (mg/kg)		REI	PHI	MNT	EDS
	$AOLD_{50}$	$AOLD_{50}$				
alpha-cypermethrin	79—400	> 2000		28	2	+
bifenthrin	♂55,5; ♀53,4	> 2000		21	1	+
cypermethrin	251—4123	> 1600	1	35	2	+
dimethoate	387	353—800	1	42	2	+
endosulfan		74—681	1	35	2	+
esfenvalerate	75—88	> 5000	1	35	2	
fenitrothion	1700	810	3	42	3	
fenthion	250	586—800	1	42	3	+
chlorpyrifos	33—56	> 2000		28	2	+
carbofuran		> 2000		PTA	1	
carbosulfan	♂182; ♀90,5	> 2000		PTA	2	
imidacloprid	400	> 5000		PTA	1	
lambda-cyhalothrine	♂68,9; ♀52,12	632—696		14	2	+
malathion	1375—2800	> 4444	2	35	2	+
methidathion		1546		21	2	+
methomyl		> 1000	2	42	3	+
monocrotophos		126—112	2	42	2	+
oxyidemeton-methyl	30—85	100—150	3	42	1	+
phoxim	> 2000	> 5000	1	35	3	

pyrimiphos methyl	♂2050; ♀1861	> 2000		28	3	
tefluthrin		♂316; ♀177		PTA	1	
terbufos				PTA	1	
thiamethoxam	1563	> 2000	1	PTA	2	

PTA — provided by time of application; MNT — maximum number of treatment in vegetation. REI — re-entry interval; PHI — pre harvest interval; EDS — endocrine disrupting substances.

Table 2. Toxicological traits of fungicides registered for sugar beet

Fungicides	for rats (mg/kg)		REI	PHI	MNT	EDS
	$AOLD_{50}$	$ADLD_{50}$				
benomyl	> 10000	> 10000		42	1	+
carbendazime	> 15000	> 2000		42	3	+
carboxin	3820	> 4000		PTA	1	
chlorothalonile	> 5.000	> 10000		21	3—4	
cyproconazole	♂1115; ♀1342	> 2000		42	3	
difenoconazole	1453	> 2000		?	1—2	+
epoxiconazole	> 5000	> 2000		42	2	+
fentin-hydroxide	♂171; ♀110	♀1600		28	2	+
fluquinconazole	112	♂2679; ♀625		PTA	2	
flusilazole	♂1110 ♀674	> 2000		21	2	+
flutriafol	♂1140; ♀1480	> 1000		35	2	
mancozeb	> 5.000	> 5000		PTA	1	+
propiconazole	1.517	> 4000		14	2	
tetraconazole	1.031—1.248	> 2000		21	2	
thiophanat-methyl	♂7500; ♀6640	> 10000		42	2	
thiram	2.600	> 2000		PTA	1	+
triforine	> 16000	> 10000		42	2	

PTA — provided by time of application; MNT — maximum number of treatment in vegetation. REI — re-entry interval; PHI — pre harvest interval; EDS — endocrine disrupting substances.

In this paper, only insecticides and fungicides traits considered more toxic and higher risk compounds than herbicides are reviewed.

The application determines safety for operator and consumers. Seed coating and in furrow applied insecticides protect the seed, seedlings and young plants: as imidacloprid, thiamethoxam, carbofuran, carbosulfan, tefluthrin, terbufos are considered safe as PHI could be respected. They are effective against *Grullotalpa, Mellolontha* larvae, wireworms, Sitona, Halticinae, weewils. Fungicide active agents protecting seedlings from seed and soil pathogens based on active ingredients mancozeb, carboxin, thiram and methalaxyl M are registered and present the risk for operators coming in contact with coated seed.

Foliar applicable products are considered to create more risk to operator as it is more difficult to respect PHI and reduce treatment frequency. Majority of insecticides are used several times during vegetation — in young plants and late in season to suppress Halticinae, aphids, Noctuid caterpillars (*Mamestra brassicae, Autographa gamma, Scotia segetum* and *S. ypsilon*), as well as against caterpillar of beet moth and other leaf pests. For the only chlorinated hydrocarbon — compound endosulfan and OP, the PHI is 30 days and it is more or less respected due to technology of beet processing.

Table 3. Ecotoxicological traits of insecticides registered for sugar beet

insecticides	DT_{50} in soil (days)	birds	fish	honey bees	earthworm
alpha-cypermethrin	91	N	V	V	H
bifenthrin	65—125	N	V	V	
cypermethrin	8—16	N	V	V	H
dimethoate	2—4,1	T	H	V	H
endosulfan	30—70	H	V	N	V
esfenvalerate	88—287	V	V	V	
fenitrothion	12—28	H	T	V	
fenthion	1,5	V	T	V	H
chlorpyrifos	33—56	H-V	V	V	H
carbofuran	30—60	V	V	V	
carbosulfan	2—5	T	V	V	V
imidacloprid	4 h	T-N	N	V	T
lambda-cyhalothrine	6—40	N	V	V	N
malathion	1—4	H	V	V	
methidathion	3—18	T	V	V	V
methomyl	10—15	T	V	V	T
monocrotophos	1—5	V	H	V	
oxyidemeton-methyl	quick	T	H	T	H
phoxim	quick	T	V	V	
pyrimiphos methyl	< 30	T	T	V	H
tefluthrin	150	H	V	V	V
terbufos	9—27	T	V	T	N
thiamethoxam	7—30	N	N	V	N

DT_{50} — half life in soil; N — non-toxic; H — harmful; T — toxic; V — very toxic.

Table 4. Ecotoxicological traits of fungicides registered for sugar beet

fungicides	DT_{50} in soil (days)	birds	fish	honey bees	earthworm
benomyl	0,75	H	V	N	T
carbendazim	18—32	N	V	H	V
carboxin	1	N	V	N	N
chlorothalonil	5—36 d	N	H	N	N
cyproconazole	90	T	H	N	H
difenoconazole	75—882	N	V	N	N
epoxiconazole	60—90	N	T	N	N

fentin-hydroxide	140	T	V	T	
fluquinconazole	50—300	N	T	N	N
flusilazole	95	H	T	N	H
flutriafol	slow	N	H	T	N
mancozeb	6—15 d	N	T	N	V
metalaxyl-M	74	H-N	N	N	N
propiconazole	40—70 d	N	T	N	N
tetraconazole		T	T	N	T
thiophanate-methyl	21—28	N	T-H	N	
thiram	0.5 d	N	V	N	H
triforine	21	N	N	N	N

N — non-toxic; H — harmful; T — toxic; V — very toxic.

The majority of sugar beet fungicides are registered for foliar treatment during summer season against *Cercospora beticola* and only one-triforin — against *Erysiphe betae.* Metalaxyl M is registered against — *Peronospora schahti* on seed beet, but the permission has expired this year. For other pathogens, no fungicides are registered in our country.

Their PHI render from 21 to 42 days, with low mammalian toxicity and the majority are eco-toxicologicaly harmless: only eight of them are very toxic to fish, two to earth worms, only three are toxic to birds and two to honey bees. But eight out of 18 are suspected of being endocrine disruptors.

ENDOCRINE DISRUPTORS IN-BETWEEN SUGAR BEET PESTICIDES

Over the last 10 to 15 years, toxicologists became involved in investigation on many pesticides and industrial chemicals capable of interfering with proper functioning of estrogen, androgen and thyroid hormones in humans and animals. These substances are called endocrine disruptors (EDS). Agricultural workers at working place or consumers by food, water or air are chronically exposed. These substances impair or disrupt the function of endocrine glands and corresponding hormones. At the beginning, the impaired fertility of fish, game and later humans was observed.

EDS are exogenous chemicals which act by variety of mechanisms, binding to hormone receptors, mimicking or antagonising the physiological functions. They could stimulate or inhibit enzymes responsible for synthesis or liberation of hormones and increase or block hormonal action or trigger inappropriate hormone activity (Sharara et al., 1998, Mumtaz et al., 2002, Allera et al., 2004, Golub et al., 2004).

Hormones play significant role in the differentiation of early embryo development, so exposure of pregnant females to these substances could alter normal development processes.

The exposure effects are visible immediately or later during the lifetime, like changes in learning ability, behaviour, reproductive capacity. The biggest attention is paid to EDS on sexual hormones and thyroid gland.

Both sexes have both hormones-estrogen responsible for female characteristics is prevalent in females and androgen — responsible for male characteristics and predominant in males. Many pesticides have estrogenic, androgenic or anti-androgenic mode of actions (D a x e n b e r g e r, 2002, A l l e r a et al., 2004, P e t r e l l i et M a n t o v a n i, 2002, M o r i n a g a et al., 2004, T o f t et al., 2004).

The EDS of this group are bio-accumulative industrial chemicals — polychlorinated biphenyls, PCB, dioxins, poly cyclic aromatic hydrocarbons — PAH, phenyl-phenol (imported in citrus fruits), chlorinated hydrocarbon insecticides as DDT, heptachlor, dieldrin, etc. — now banned and endosulfan which is still permitted in sugar beet, even in fruit and potato.

These substances induce early sexual maturity, disorders of functions, sterility and accelerated loss of fertility.

Antiandrogenic EDS cause the alteration of behaviour, structural deformities of reproductive organs, including inter sexual types, influence reproductive capacity of males and females, spontaneous miscarriages, premature delivery, increased genitourinary malformations of the new born and increase incidence of cancer. The demasculinization of male and virilization of female rats (loss of masculine traits in males and feminine in females). Fungicides of benzimidazole class (benomyl), phtalimide (captan), triphenyltin compounds (fentin-acetate and -hydroxide) triazole derivatives (difenoconazole, epoxicinazole) act anti-androgenic as well as certain synthetic pyrethroides (cypermethrin, esfenvalerate), some chlorinated hydrocarbon and methyl-carbamate insecticides (dimethoate, methidathion, methomyl etc.).

Chronic exposures to organic phosphorous and methyl-carbamates have special effects. Besides influence on sexual hormones, the slowdown reactivation of acetylcholine esterase responsible for acetylcholine degradation and causing retarded reaction characteristic for old age.

Prenatal exposure to pesticide affects thyroid gland functioning responsible for brain development — (intelligence and memory). Professionally exposed persons, employed on the production and application of ED pesticides, may suffer of disfunction of thyroid gland, goitre, malignant tumours etc. For thyroid obstruction herbicides linuron, atrazine, alachlor, amitrole and dithiocarbamate fungicides (zineb, ziram, thiram, mancozeb) are being suspected.

DISCUSSION AND CONCLUSION

The majority of insecticides for sugar beet protection are toxic or highly toxic, but fungicides and herbicides are of low toxicity, or harmless for mammals and other beneficial organisms. Products suspected of being endocrine disruptors are present in all three groups.

In between insecticides approved for sugar beet, 15 are very toxic to fish and 20 to honey bees. Long half-life in soil have endosulfan, bifenthrin, esfenvalerate, chlorpyrifos, carbofuran, tefluthrin. The risks and hazards in the sense of way and frequency of application of these insecticides as well as fungicides with long soil half-life as triazole derivatives and suspected endocrine disruptors should be re-evaluated.

It would be of major importance to publish this EC list in open and to mandatory oblige every producer to state clearly ES status and re-entry interval, especially for OP and methyl-carbamate compounds. In some countries, REI are elaborated upon plant species, degree of development and way of application (Anonymous, 2004). This is very important from the point of chronic exposure and maximum protection of workers. Only nine insecticides are permitted to be used from aircraft and six of them are suspected as EDS, but maximum buffer zone to waterways and settlements are stated.

We suggest obligatory submission of data on endocrine disruption potentials for pesticide registration and mandatory warning of agriculture producers by publishing these data in handbooks or through other means as government agriculture extension services. The necessary precaution steps in timing of pesticide application would become apparent to every agricultural producer when planning pesticide usage schedule in sugar beet protection. ED pesticide should be avoided or number of treatments reduced to minimum, or replaced by less danger pesticides whenever possible.

It would be desirable to acquire from the "EC strategy act on the sustainable use of pesticides" the scenario and form the national plan to reduce hazard and risks of exclusive dependence on chemicals. The plan should include mandatory education/certification of sprayers, farmers and professional pest control operators, mandatory education of pesticide retailers, distributors; mandatory pesticide training and accreditation for crop protection advisers and agricultural extension officials, extension services/programmes promoting need-based models (decision support, warning systems).

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ВИСОКОРИЗИЧНИ ПЕСТИЦИДИ У ЗАШТИТИ ШЕЋЕРНЕ РЕПЕ

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Резиме

Особине пестицида дозвољених за примену у шећерној репи (акутна орална, дермална и инхалациона токсичност, токсичност за дивљач, пчеле и акватичне организме, утицај на репродукцију и ендокрини систем, радна каренца, максималан број третирања у току вегетације уз поштовање добре пољопривредне праксе) указују да нема опасности за раднике у производњи шећера, али има при примени (хронична изложеност), нарочито од средстава с ефектима на ендокрини систем (фентин-ацетат, беномил, ендосулфан, метомил, метидатион). Ендокрини дисраптори могу проузроковати стерилност, смањити фертилност, омести развој, изазвати поремећаје репродуктивних органа новорођенчади као и метаболичке сметње. Препоручује се ограничена примена пестицида ендокриних дисраптора (највише једном у вегетацији), замена некима мање ризичним по здравље људи, дивљачи и риба као и обавезно укључивање радне каренце при регистрацији.

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STATE OF WEED INFESTATION AND FEATURES OF SUGAR BEET PROTECTION IN BELARUS*

ABSTRACT: The changes of phytosanitary situation recently taking place in sugar beet crops in the Republic of Belarus are shown. It is noticed that in the crop agrocoenosises there is a high infestation level caused by Japanese barnyard millet (*Echinochloa crus-galli* (L.) Pal. Beauv.), field sowthistle (*Sonchus arvensis* L.), chickweed (*Stellaria media* (L) Vill.), quick grass (*Agropyron repens* (L.) Pal Beauv.), matricary (*Matricaria perforate* Merat), creeping thistle (*Circium arvense* (L.) scop), marsh woundwort (*Stachus palustris* L.), wild buckwheat (*Polygonum convolvulus* L.), bristle stem hemp nettle (*Galeopsis tetrahit* L.), common horsetail (*Equisetum arvense* L.), field forget-me-not (*Myosotis arvensis* (L.) Hill.), shepherd's purse (*Capsella bursa-pastoris* (L.) Med.) etc. Due to non-observance of preventive and separate agrotechnical techniques especially in spring-summer period, such weeds as *bedstraw* (*Galium aparine* L.), white campion (*Melandrium album* (Mill.) Garcke), green amaranthus (*Amaranthus retroflexus* L.) started to appear in the crops. To protect sugar beet effectively, two variants of herbicides application are proposed. The first one — a combined, one stipulating soil action herbicides application before planting or before sugar beet seedlings emergence and on seedlings — to carry out two treatment by post-emergence preparations. The second variant, a split post-emergence herbicide application (two-three times spraying) on growing weeds at small application rates. In the next 5—6 years, a combined method will be of a primary importance in the conditions of the Republic.

KEY WORDS: agrocoenosis, specific composition, herbicides, sugar beet, weed plants, phytosanitary condition

INTRODUCTION

One of the elements for obtaining high sugar beet yields and the correspondent sugar output per unit area is a wide introduction of measures on the effective eradication of weed plants in the crops. However, the development of

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the effective measures on weed extirpation and spread prevention is possible only on the bases of the detailed study of their specific composition, biological features of growth and development, regularities of species change and also on the bases of degree of their harmfulness, spread and occurrence in sugar beet agrocoenosises. Based on the data of the "Institute of plant protection", National Academy of Sciences of Belarus (K. P. P a d i o n o v et al., 2004), a joint sugar beet growing with weeds is allowed for not more than 15 days from the moment of the crop seedlings appearance. The herbicide application is the most expedient during this period. By combined growing of sugar beet with weeds in the course of 30 days, the root crop yield is decreased up to 45%.

In order to decrease sugar beet weed infestation, a complex of agrotechnical, organizational, chemical and other measures is necessary. However, the most available and justifiable technique is the application of herbicides against the background of high agronomical practices. Thus, to carry out the protective measures effectively, it is necessary to have the information on the character of weed plants growing in the crops and their quantitative and specific diversity on the plot, spectrum of preparation actions, soil peculiarities, weather and other conditions. However, their application is an expensive measure since a significant yield portion is used to cover the expenses for getting herbicides. Based on our calculations, even the minimum expenses for carrying out protective measures are justified only by obtaining root crop yield within the range of 300 cwt/ha. Based on K. P. P a d i o n o v (2002) data, a root crop return for the expenses against the background of pre-planting Vitox, 72% EC application (EPTC) makes 49—55 cwt/ha. Against pre-planting or pre-emergence application of Piramin turbo, 520 g/l SC (chloridazon) makes 67—82 cwt/ha, Goltix, SC and WP (metamitron, 700 g/l, 700 g/kg) — 95—110 cwt/ha; against the background of post-emergence herbicide application based on phenmedipham and desmedipham (three times spraying) pure and in combination with the preparations of other spectrum of activities (the preparations based on chloridazon, metamitron, sulfonylurea) it makes 33—115 cwt/ha at a price of 30 USD per one ton of root crops.

PLACE AND METHOD OF RESEARCHES

The determination of specific composition and weed plant number in different zones of the Republic was done by way of itinerary inspections of sugar beet weed infestation and the herbicide efficiency study on the experimental field of the RUE "Institute of plant protection" National Academy of Sciences of Belarus (p. Priluki, Minsk region) and in sugar beet planting farms of the Republic following general methods.

The climatic conditions of sugar beet growing regions of Belarus are favorable for sugar beet cultivation. The duration of a vegetation period is 180 days (from April, 15 till October, 20). The average daily sum of temperatures during the vegetation period exceeds 2000°C, which is quite enough for sugar beet growth and development. There is a high precipitation level — 600—700 mm in a year in Belarus. In the western regions more than half of the annual precipitation norm falls in spring-summer period, among them near 108 mm come in April-May, in June and August the amount of precipitation is 249—277 mm. Thus, in July and August, such important months for sugar beet development, the precipitation makes 85—90 mm. In autumn, the precipitation norm fluctuates within the range of 142—147 mm (V. D. T i m o s h i n i n et al., 1956). The characteristic feature of western districts of Belarus climate is uneven spread of rainfall and warmth in the course of the year. Often, the years are marked when the rainfall amount and the sum of positive air temperatures, on average, correspond to the norm, but their distribution over months of vegetation period takes place irregularly and unfavorably for sugar beet (N. P. V o s t r u k h i n a, 1978).

In soil covering of arable land of Belarus, a prevalent type are soddy-podzolic soils with different degree of podzolization of the upper layer. They occupy 94,5% of arable land. By mechanical composition, soddy-podzolic loamy and sandy soils are prevalent (N. P. V o s t r u k h i n, 1974).

RESULTS OF RESEARCHES

As the result of itinerary inspections, it is determined that even after chemical weeding, the most often met in sugar beet (at leaf closing stage in inter-rows) are Japanese barnyard millet (*Echinochloa crus-galli* (L.) P a l. B e a u v.), quick grass (*Agropyron repens* (L) P a l . B e a u v r.), chickweed (*Stellaria media* (L) V i l l.), fat hen (*Chenopodium album* L.), field violet (*Viola arvensis* M u r r.), matricary (*Matricaria perforate* M e r a t), wild buckwheat (*Polygonum convolvulus* L.) (Table 1).

Table 1. Weed plants occurrence in sugar beet crops (Itinerary inspection)

Weed plant species	1979	1996—2000	2001	2003	2004
Fat hen (*Chenopodium album* L.)	xxx	xxx	xxx	xx	xx
Quick grass (*Agropyron repens* (L.) P a l . B e a u v.)	—	xxx	xx	xx	xx
Green amaranth (*Amaranthus retroflexus* L.)	—	xxx	xx	xx	x
Japanes barnyard millet (*Echinochloa crus-galli* (L.) P a l . B e a u v.)	x	xxx	xx	xx	xxx
Matricary (*Matricaria perforata* M e r a t)	xxx	xxx	xxx	xx	xx
Knotgrass (*Polygonum aviculare* L.)	xx	xx	xxx	xxx	x
Wild buckwheat (*Polygonum convolvulus* L.)	xx	xx	xxx	xx	xx
Lady's-thumb (*Polygonum persicaria* L.)	—	—	x	x	x
Scabiose knotweed (*Polygonum lapathifolium* L.)	xx	xx	xx	xx	x
Creeping thistle (*Cirsium arvense* (L.) S c o p.)	xx	xx	xx	x	x
Field forget-me-not (*Myosotis arvensis* (L.) H i l l.)	x	—	x	x	x
Chickweed (*Stellaria media* (L.) V i l l.)	—	xx	xx	x	xx
Cornflower (*Centaurea cyanus* L.)	x	x	x	x	x
Shepherd's purse (*Capsella bursa-pastoris* (L.) M e d.)	xxx	—	xx	x	xx
Field sow thistle (*Sonchus arvensis* L.)	xx	xx	x	x	xx
Bristle stem hemp nettle (*Galeopsis tetrahit* L.)	xx	x	x	x	x

White campion (*Melandrium album* (M i l l.) G a r c k e)	—	x	xx	xx	x
Annual meadowgrass (*Poa annua* L.)	x	x	x	x	x
Field spurry (*Spergula arvensis* L.)	—	x	xx	x	x
Marsh woundwort (*Stachus palustris* L.)	—	x	x	x	x
Mugwort (*Artemisia vulgaris* L.)	x	x	—	—	—
Common speedwell (*Veronica arvensis* L.)	—	—	—	x	x
Field violet (*Viola arvensis* M u r r.)	—	—	xxx	xx	xx
Common horsetail (*Equisetum arvense* L.)	—	x	x	x	x
Common dandelion (*Taraxacum officinale* W e b.)	—	—	—	x	x

Note: xxx — weed plants occurrence on 75—100% of fields; xx — occurrence on 30—70% of fields; x — up to 30% of fields.

From the remaining weed plants, depending on the year of researches, the annual weeds are presented by 12—16 species, among them 10—14 — dicotyledonous (Table 2). Perennial weeds are presented by 3—5 species: quick grass (*Agropyron repens* (L.) P a l. B e a u v.), field sowthistle (*Sonchus arvensis* L.), creeping thistle (*Cirsium arvense* (L.) s c o p.), common hors tail (*Equisetum arvense* L.), marsh woundwort (*Stachus palustris* L.) or field mint (*Mentha arvensis* L.). The specific composition of weed plants after weeding differs by districts of the Republic: in Brest district — 24 species are met, Minsk — 20, Vitebsk — 17, Mogiliov — 12, Gomel and Grodno — 9 and 8 species, accordingly.

Table 2. Specific weed plant composition in sugar beet crops (Itinerary inspection at leaf closure in inter-rows stage)

	Number of weed plant species, weed plants			
	1996—2000	2001	2003	2004
	On the average in Belarus			
Total species number:	19	18	21	15
Annual	14	14	16	12
including dicotyledonous	12	13	14	10
Grass	2	1	2	2
Perennial	5	4	5	3
including dicotyledonous	4	2	3	2
Grass	1	1	1	1
Spore		1	1	

On average, in the Republic, 27—40 weed plants/m^2 grow before sugar beet harvest (Table 3), which is 4—9 times above the threshold of harmfulness. Dominate Japanese barnyard millet (*Echinochloa crus-galli* (L.) P a l. B e a u v.) has 7,1 weed plants/m^2, quick grass (*Agropyron repens* (L.) P a l. B e a u v.) has 6,9 weed plants/m^2, chickweed (*Stellaria media* (L.) V i l l.) has 4,9 weed plants/m^2, fat hen (*Chenopodium album* L.) has 3,8 weed plants/m^2, field violet (*Viola arvensis* M u r r.) has 1,9 weed plants/m^2, matricary (*Matricaria perforate* M e r a t) has 1,0 weed plants/m^2.

Table 3. Sugar beet weed infestation (Itinerary inspection at leaf closure in inter-row stage)

	Weed plants number, weed plants/m^2		
	2001	2003	2004
On the average in the Republic			
Total number of weeds:	27	36	40
Annual	22	31	31
including dicotyledonous	19	27	24
Grass	3	4	7
Perennial	5	5	9
including dicotyledonous	2	2	1
Grass	3	3	7
Spore			1
Threshold of harmfulness — 3—10 weed plants/m^2			

Significant differences in sugar beet weed infestation by districts — in Brest district, 94 weed plants/m^2, Minsk, 20, Grodno, 17, Vitebsk, 81, Mogiliov, 16 and Gomel, 12 weed plants/m^2. Annual group weed plant number fluctuated from 8 weed plants/m^2 in Mogiliov district up to 84 weed plants/m^2 in Brest; perennial, from 3 weed plants/m^2 in Grodno district to 26 in Vitebsk.

Analyzing sugar beet weed infestation data, one can make conclusions that on the whole infestation decreased for the last 3—5 years in the Republic. However, weed infestation by Japanese barnyard millet (*Echinochloa crus-galli* (L.) Pal. Beauv.), field sowthistle (*Sonchus arvensis* L.), chickweed (*Stellaria media* (L.) Vill), quick grass (*Agropyron repens* (L.) Pal. Beauv.), matricary (*Matricaria perforate* Merat), creeping thistle (*Circium arvense* (L.) Scop), marsh woundwort (*Stachus palustris* L.), wild buckwheat (*Polygonum convolvulus* L.), bristle stem hemp nettle (*Galeopsis tetrachit* L.), common horsetail (*Equisetum arvense* L.), field forget-me-not (*Myosotis arvensis* (L.) Hill.), shepherd's purse (*Capsella bursa-pastoris* (L.) Med.) etc. remains high. Before 2001, there was no field violet (*Viola arvensis Murr*.); starting with 2004, common dandelion (*Taraxacum officinale* Web.) and wall speedwell (*Veronica arvensis* L.) appeared in sugar beet crops. The main reason for perennial weed plant number increase (quick grass (*Agropyron repens* (L.) Pal. Beauv.), field sowthistle (*Sonchus arvensis* L.), creeping thistle (*Cirsium arvense* (L.) Scop.) etc.) is the insufficient use of bastard fallow soil tillage technique. Due to non-observance of preventive and separate agrotechnical techniques especially in spring-summer period on separate fields, dominate bedstraw (*Galium aparine* L.), white campion (*Melandrium album* (Mill.) Garcke), green amaranthus (*Amaranthus retroflexus* L.).

In order to carry out the effective protective measures, the main parameters of herbicides application are developed at the "Institute of plant protection", taking into account time and methods of their application depending on weed plant spectrum and the dynamics of coenosis formation, soil features, weather and other conditions. Optimum time for herbicide treatment is determined by persistent, dominating weeds such as green amaranthus (*Amaranthus* *retroflexus* L.), jointweed (*Polygonaceae* spp.), bedstraw (*Galium aparine* L.), bristle stem hemp nettle (*Galeopsis tetrachit* L.), fat hen (*Chenopodium album* L.) etc.

Taking into account the fact that sugar beet is very sensitive to weeds at early stages of development, it is necessary to carry out this crop protection against perennial weeds during autumn soil preparation using common eradicative action herbicides based on glyphosate: Roundup, 360 g/l a.s.; Glyphogan, 360 g/l a.s.; Glialka, 360 g/l a.s.; Uragan, AS; Belphosate, 360 g/l a.s.; Pilaraund, 360 g/l a.s. etc., at the rates of application of 4,0—6,0 l/ha. Perennial weed plant infestation is decreased for 85—955, which allows carrying out measures on soil preparation, fertilizers application and sugar beet planting the next year at a high quality level.

During sugar beet vegetation to extirpate weeds germinated in fields, two variants of herbicides application are recommended. A combined one, stipulating pre-planting or before sugar beet seedlings emergence application of soil herbicides (Goltix, SC and WP (metamitron, 700 g/l, 700 g/kg), Pilot, WWC (metamitron, 700 g/l), Yutix, SC (metamitron, 700 g/l), Piramin turbo, 52% g/l SC (Chloridazon) — (2—3 l/ha); Lenacil BetaMax, WP (lenacil, 800 g/kg) — (1,0 kg/ha); Dual gold, EC (C-Metolachlor, 960 g/l EC (dimetenamide-II) — (1,0—1,2 l/ha) and their mixtures) and on seedlings — the preparations based on phenmedipmam and desmedipham. Vitox, 72% EC (EPTC) (2,8—5,6 l/ha) is applied only before crop planting with the immediate incorporation, within 15—20 minutes. A combined variant of herbicides application is the most applicable at sufficient soil moisture content.

In dry hot weather or under insufficient rainfall precipitation (especially at the beginning of vegetation period or in sugar beet planting on spring ploughing, it is recommended to use herbicides by split post-emergent application at small application rates, three times, considering weed plant development stages. Betanal progress AM, EC (desmedipham, 60 g/l + phenmedipham, 60 g/l + ethofumesate, 60 g/l) — (1,5 + 1,5 + 1,5 l/ha); Betanal expert OF, EC EC (desmedipham, 71 g/l + phenmedipham, 91 g/l + ethofumesate, 112 g/l) or Betanes, EC (desmedipham, 70 g/l + phenmedipham, 90 g/l + ethofumesate, 110 g/l) — (1,0 + 1,0 + 1,0 l/ha); Biphor, EC (desmedipham, 80 g/l + phenmedipham, 80 g/l) — (1,5 + 2,0 + 2,0 l/ha); Betanal AM 11, EC (desmedipham, 80 g/l + phenmedipham, 80 g/l) — (2,0 + 2,0 + 2,0 l/ha); Agrybit (Bitape FD 11), 16% EC. (desmedipham, 8% + phenmedipham, 8%) — (1,5 + 2,0 + 2,0 l/ha); Karibu, 50% WP (triflusulfuronmethyl) — (30 g/ha + 200 ml/ha of Surfactant Trend 90 at every treatment). Post-emergence herbicides can be used both as an independent technique and in a tank mixture with herbicides of other spectrum of action (preparations based on chloridazon, metamitron or sulfonylurea). The first treatment by post-emergence herbicides is done at cotyledon leaf stage of weed plants, the second and the subsequent ones at 7—14 days interval, after the appearance of new weed plant seedlings. Sugar beet stage of development does not play a significant role.

In case of no application of herbicides derivatives of glyphosate, in autumn against perennial dicotyledonous weeds (*creeping thistle, field sowthistle*) and also *matricary*, *jointweed*, *corn flower lontrel*, 300, 30% a.s. (clopyralid) is added to betanal group preparations — (0,3—0,4 l/ha), against *quick grass* and annual grass weeds, one of grass action preparations (Targa super, 5% EC (Quizalofop-II-ethyl) — (1,0—2,0 l/ha); Leopard, 5% EC (quizalofop-II-ethyl, 50 g/l) — (1,0—2,0 l/ha), Miura, EC (quizalofop-II-ethyl, 125 g/l) — (0,4—1,2 l/ha); Panther, 4% EC. (quizalofop-II-tephuryl) — (0,75—1,5 l/ha); Target, EC (quizalofop-II-ethyl, 51,6 g/l) — (1,0—2,0 l/ha); Zellec super, EC (galoxyfop-R-etoxymethyl acid, 104 g/l) — (0,5—1,0 l/ha; Fusilade forte, EC (fluazifop-II-butyl, 150 g/l); Aramo, 50 g/l EC (tetraloxydim, 50 g/l) — (1,5—2,0 l/ha).

The most widely used herbicide systems:

— before planting with the immediate incorporation: Vitox (2,8—5,6 l/ha), before planting or before sugar beet seedlings emergence — Goltix, Pilot or Piramin Turbo (2,0—3,0 l/ha) or a mixture of any of these preparations at half application rates;

— after sugar beet seedlings emergence: the first treatment — Goltix, Pilot or Piramin turbo (1,5 l/ha) + betanal group preparations (1,2—2,0 l/ha) and if it is necessary to add lontrel — 0,3—0,5 l/ha and one of grass herbicides (1,5—2,0 l/ha). The second treatment can be carried out only by betanal group preparations or with the addition of Goltix, Pilot or Piramin turbo at the application rates of 1,5—2,0 l/ha;

— two or three times herbicide application gives an opportunity to avoid inter-row treatments in order to prevent root system damage by treatment instruments and soil compaction. By such herbicide application, the active ingredients of preparations are more quickly decomposed in soil and plants, which promotes the improvement of ecological situation.

CONCLUSIONS

The evaluation of the dynamics of formation and specific composition of weed plant changes gives an opportunity to form an optimum assortment of herbicides and prevent the formation of resistant weed plants as well as it enables preventing the accumulation of herbicide residues in the environment.

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СТАЊЕ КОРОВСКЕ ЗАРАЖЕНОСТИ И КАРАКТЕРИСТИКЕ ЗАШТИТЕ ШЕЋЕРНЕ РЕПЕ У БЕЛОРУСИЈИ

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Резиме

Зараженост шећерне репе коровима у Белорусији значајно надмашује прагове штетности корова и претпоставка је интензивне примене хербицидног асортимана који би требало стално обнављати. Сада се у шећерној репи користе две варијанте примене хербицида. Прва је усмерена на употребу земљишних хербицида пре сетве или пре ницања клијанаца шећерне репе, и на клијанцима — извођењем два третмана са хербицидима после ницања. Друга варијанта је сплит пост-емергентна примена хербицида (2—3 прскања) при ниским дозама примене на корове у вегетацији. За најмање 5—6 година због објективних разлога комбинована варијанта ће бити од превасходне важности.

Узимајући у обзир ове карактеристике, недавно су у РУЦ „Институту за заштиту биља” НАС из Белорусије истраживачи радили не само у једном смеру подизања биолошке ефикасности примењених хербицида, него и у количини њихове примене и смањењу токсичности у објектима животне средине. Да би се усеви шећерне репе ефикасно заштитили од коровских биљака, неопходно је имати податке о специфичном диверзитету, биолошким карактеристикама раста и развоја, динамици формирања и специфичностима промена врста, броју коровских биљака и штетности. На основу тога, у раду ће бити представљени резултати вишегодишњег мониторинга заражености шећерне репе у републици, као и ефикасност низа перспективних хербицида примењених у технологији узгоја усева. Приказани ће бити и системи заштите који узимају у обзир динамику формирања коровске ценозе, специфичан састав коровске биљке, спектар хербицида, особине земљишта, време и други услови.

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OCCURRENCE, SPREAD AND POSSIBILITIES OF INVASIVE WEEDS CONTROL IN SUGAR BEET*

ABSTRACT: Floristically rich and diverse weed comunity of sugar beet is in our country represented by 150 weed species. They are not all equaly significant in weediness of this crop. Only a limited number of them participate in weed comunity composition. These are: *Abuthilon theophrasti* Medic., *Ambrosia artemisiifolia* L., *Amaranthus retroflexus* L., *Chenopodium album* L., *Cirsium arvense* (L.) Scop., *Convolvulus arvensis* L., *Cynodon dactylon* (L.) Pers., *Digitaria sanguinalis* (L.) Scop., *Hibiscus trionum* L., *Rubus caesius* L., *Echinochloa crus-gall* L., *Polygonum aviculare* L., *P. lapathifolium* L., *P. persicaria* L., *Setaria glauca* (L.) P. B., *S. viridis* (L.) P. B., *Solanum nigrum* L. and *Sorghum halepense* (L.) Pers. In shooting period up to 4—8 weeks upon emergence, sugar beet is under the haviest harmfull inluence of weeds, especially invasive ones such as: *Abuthilon theophrasti* Medic., *Ambrosia artemisiifolia* L., *Cirsium arvense* (L.) Scop., *Iva xanthifolia* L., *Sorghum halepense* (L.) Pers. and *Xanthium strumarium* L. Sugar beet growing requires intensive cultural practices, i.e. basic and additional tillage and cultivation. Due to the widening of weed problems, frequent herbicide use in several applications is needed in the longer time period.

KEY WORDS: control, invasive weed species, herbicides, sugar beet

INTRODUCTION

Sugar beet is broadcast planted spring row crop that gives the highest yield per unit of area. It is highly demanding regarding human labor and machinery use. Along with other means of protection, weed control must be paidd special attention in order to achieve high yields. Because of exceptional susceptibility of sugar beet regarding the harmful influence of weeds, more successful yield and higher suggar content are provided by their control. Besides, herbicide use is economically justified for human labor costs are dicreased, as well as interrow cultivation and hoeing (Konstantinović, 1999). The

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beggining of plant development is the most susceptible period for weed control and herbicide use. Therefore, it demands great attention of specialists as well as plant protection against weeds by corresponding weed-killers. Relatively broad free interrow distance in early phases of sugar beet development and low capacity of competing enables fast spreading of weeds. Successful control of competing weed plants increases leaf mass, root and sugar content per area of unit. Early sowing and crop growth rate, method of growing and sugar beet cultivation, as well as its planting density and coverage enable the development of characteristic weed vegetation (Konstantinović and Marković, 2000). Equation of agroecological conditions for sugar beet growing creates conditions for the occurrence of relatively small number of weed species in comparison to other row crops. By the beggining of spring, upon sugar beet emergence until closing of the rows, the most frequent weed species are: *Fumaria officinalis* L. (spring ephemeres), *Capsella bursa-pastoris* (L.) Medic., *Viola arvensis* Murr. (winter and spring weeds), *Polygonum convolvulus* L. (early spring weeds) and *Sinapis arvensis* L. (Kojić et al., 1972).

By the end of spring, late spring and perrenial weeds that overgrow and often are higher than sugar beet plants emerge. Of these, the most frequent are: *Amaranthus retroflexus* L., *Abutilon theophrasti* Medic., *Ambrosia artemisiifolia* L., *Chenopodium album* L., *Datura stramonium* L., *Echinochloa crus-galli* L., *Setaria glauca* (L.) P. B., *S. viridis* (L.) P. B. and *Sorghum halepense* (L.) Pers. In comparison with grass weeds, broad-leaved weeds that overgrow and overshadow sugar beet cause more damage (Konstantinović et al., 2001).

In shooting period up to 4—8 weeks upon emergence, sugar beet is under severe harmful inluence of weeds, especially invasive ones such as: *Abuthilon theophrasti* Medic., *Ambrosia artemisiifolia* L., *Cirsium arvense* (L.) Scop., *Iva xanthifolia* L., *Sorghum halepense* (L.) Pers. and *Xanthium strumarium* L. (Konstantinović and Meseldžija, 2001). Sugar beet growing demands intensive cultural practice, including basic and additional soil tillage, as well as crop cultivation. Due to the broadening of weed problems, herbicides frequently need to be used several times and in a longer time period (Naylor, 2002). Herbicides can be applied before sowing with incorporation, or after sowing, but before shooting with later herbicide use for post--emergence weed control of *Ambrosia artemisiifoli* L., *Cirsium arvense* (L.) Scop., *Sorghum halepense* (L.) Pers., from rhyzomes, *Xanthium strumarium* L., *Iva xanthifolia* L. and other invasive weeds. These combinations lead to more efficient protection in longer time period with reduced risk that emerges from inconveniant weather conditions. Optimum application time for the first treatment is in the weed phase from shooting up to 2 leaves. The second treatment is perfomed in the phase of 4 developed weed leaves and eventually, the third one, after repeated weed occurrence, i.e. 7—10 days after the second treatment (Konstantinović et al., 2001).

If a pan, or farrowing occure after emergence, crop cultivation measures include cultivating before emergence. Both of these masures are efficient in the control of weeds in early phases of sugar beet and weed development. After emergence up to closing of the rows, several interrow cultivations are to be performed. In the zone of rows, hand hoeing is to be accomplished. Optimal period for the first hoeing is after formation of the first pair of leaves in 2—5 cm of depth, whereas for the first cultivation, the optimal period is before sugar beet thinning and the second one after the formation of the final composition of plants. Each following cultivation is performed after repeated emergence of weeds up to closing of the sugar beet rows. It is more efficient to perform more interrow cultivations and less hoeing within the row. Application of cultural practices solves the problem of weeds only for a limited time period, for in certain periods, depending predominantly upon meteorological conditions renewal of weed comunity occurs (Konstantinović, 1999).

There is a great number of herbicides that are convenient for using in sugar beet. However, due to the relatively narrow spectrum of action, low persistence and selectivity and with the aim of sugar beet protection during the whole of the vegetation period repeated treatments in low rates, i.e. split application and the use of more different herbicides are needed (Hance and Holly, 1990).

MATERIAL AND METHODS

During 2004 and 2005, herbicide trials in sugar beet crops (Table 1.) were set up in two locations, Bački Maglić and Čurug according to the standard EPPO/OEPP methods (Anonymous, 1998) in randomized block design in four replications. Trial plot size was 5 x 5 m exp (2). Applied water quantity was 300 l/ha. Control plot, which was free of herbicide treatment was also set up in the trial and was used for calculating the herbicide efficiency coefficient.

Table 1. Herbicides and herbicide combinations used in the trials

No.	Herbicides	Active ingredients	Applied quantity (kg; lx ha exp (–1))	Application time
1	Frontier super + (Tornado + Ethosat)	dimethenamid + (metamitron + ethofumesate)	1.0 + (3 + 2) x 2	pre. em. + (2 i 4 leaves)
2	Frontier super + Synbetan p forte	dimethenamid + phenmedipham + ethofumesate	1.2 + (2.5) x 2	pre. em. + (2 i 4 leaves)
3	Frontier super + Synbetan d forte	dimethenamid + desmedipham + ethofumesate	1.4 + (2.5) x 2	pre. em. + (2 i 4 leaves)
4	Synbetan p forte + Tornado	phenmedipham + ethofumesate + metamitron	(2.5 + 2) x 2	cotiledons + 2 leaves + 4 leaves
5	Synbetan d forte + Tornado	desmedipham + ethofumesate + metamitron	(2.5 + 2) x 2	cotiledons + 2 leaves + 4 leaves
6	Agrobet super	phenmedipham + desmedipham	3 + 3	2 leaves + 4 leaves
7	Safari 50 WG + Trend-90 + Synbetan p forte	triflusulfuron-methyl + (izodecil alcohol etoksilat) + phenmedipham + ethofumesate	(0.03 + 0.05% + 2.5) x 2	2 leaves + 4 leaves
8	Safari 50 WG + Trend-90 + Betanal AM 11 New	triflusulfuron-methyl + (izodecil alcohol etoksilat) + desmedipham + phenmedipham	(0.03 + 0.05% + 2.5) x 2	2 leaves + 4 leaves

9	Proponit + Agil 100 EC	propisochlor + propaquizafop	1.8 + 1.0	pre. em. + post. em.
10	Proponit + Gallant super	propisochlor + haloxyfop-P-methyl	2.5 + 1.0	pre. em. + post. em.
11	Lontrel 100	clopyralid	1.2	post. em.
12	Goltix	metamitron	6.0	pre. em.
13	Control	—	—	—

RESULTS OF THE STUDY

Durign two years of the herbicide combinations studies in sugar beet crops in locations Bački Maglić and Čurug, dominant weed species were: *Amutilon theophrasti* Medic., *Ambrosia artemisiifolia* L., *Amaranthus retroflexus* L., *Chenopodium album* L., *Chenopodium hybridum* L., *Cirsium arvense* (L.) Scop., *Datura stramonium* L., *Echinocloa crus-galli* L., *Iva xanthifolia* L., *Polygonum persicaria* L., *Sinapis arvensis* L., *Sorghum halepense* (L.) Scop. and *Xanthim strumarium* L. The efficiency coeficients of the applied herbicides against invasive weed species present in the trials (*Abutilon thoephrasti* Medic., *Ambrosia artemisiifolia* L., *Cirsium arvense* (L.) Scop., *Iva xanthifolia* L, *Sorghum halepense* (L.) Pers., *Xanthium strumarium* L.) are given in Table 2.

Table 2. Efficiency of the applied herbicides against invasive weed species

No.	Herbicides	Efficiency coefficient (%)					
		ABTH	AMAR	CIAR	IVXA	SOHA	XAST
1	Frontier super + (Tornado + Etosat)	76	98	74	84	—	70
2	Frontier super + Synbetan p forte	72	86	54	94	—	66
3	Frontier super + Synbetan d forte	79	68	46	75	—	57
4	Synbetan p forte + Tornado	71	92	76	81	—	69
5	Synbetan d forte + Tornado	69	94	78	83	—	71
6	Agrobet super	79	96	81	92	—	98
7	Safari 50 WG + Trend-90 + Synbetan p forte	98	96	71	84	—	67
8	Safari 50 WG + Trend-90 + Betanal AM 11 New	96	95	84	99	—	78
9	Proponit + Agil 100 EC	98	96	76	97	98	80
10	Proponit + Gallant super	90	94	81	96	96	80
11	Lontrel 100	94	96	91	87	—	90
12	Goltix	81	99	83	96	—	80

Remark: ABTH — *Abutilon theophrasti*; AMAR — *Ambrosia artemisiifolia*; CIAR — *Cirsium arvense*; IVXA — *Iva xanthifolia*; SAHA — *Sorghum halepense*; XAST — *Xanthium strumarium*

DISCUSSION

During two years of studies of herbicides and their combinations in sugar beet crops, the following weed species were dominant: *Abutilon theophrasti* Medic., *Ambrosia artemisiifolia* L., *Cirsium arvense* (L.) Scop., *Iva xanthifolia* L., *Sorghum halepense* (L.) Pers. and *Xanthium strumarium* L. The most efficient in the control of the present weed vegetation were combinations of herbicides with different modes of action: triflusulfuron-methyl + phenmedipham + ethofumesate and triflusulfuron-methyl + desmedipham + phenmedipham. The highest efficiency against grass species, *Sorghum halepense* (L.) Pers. which was 96—98% showed the phenoxy group of herbicides, propaquizafop and haloxyfop, whereas the remaining herbicides were used only for the control of broad-leaved weed species. *Cirsium arvense* (L.) Scop. was the most efficiently controlled by herbicide Lontrel 100 based upon active the clopyralid ingredient.

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ПОЈАВА, ШИРЕЊЕ И МОГУЋНОСТИ СУЗБИЈАЊА ИНВАЗИВНИХ КОРОВА У ШЕЋЕРНОЈ РЕПИ

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Резиме

Коровска заједница шећерне репе је флористички богата и разноврсна, а код нас броји око 150 коровских врста које немају подједнак значај у закоровљивању овог усева. Само мањи број врста учествује у изградњи карактеристичног скупа коровске заједнице: *Abuthilon theophrasti* Medic., *Ambrosia artemisiifolia* L., *Amaranthus retroflexus* L., *Chenopodium album* L., *Cirsium arvense* (L.) Scop., *Convolvulus arvensis* L., *Cynodon dactylon* (L.) Pers., *Digitaria sanguinalis* (L.) Scop., *Hibiscus trionum* L., *Rubus caesius* L., *Echinochloa crus-galli* L., *Polygonum aviculare* L., *P. lapathifolium* L., *P. persicaria* L., *Setaria glauca* (L.) P. B., *S. viridis* (L.) P. B., *Solanum nigrum* L., *Sorghum halepense* (L.) Pers. У периоду ницања па до 4—8 недеља након ницања, шећерна репа је највише изложена штетном дејству корова, нарочито инвазивних врста као што су: *Abuthilon theophrasti* Medic., *Ambrosia artemisiifolia* L., *Cirsium arvense* (L.) Scop., *Iva xanthifolia* L., *Sorghum halepense* (L.) Pers. и *Xanthium strumarium* L. За гајење шећерне репе потребне су интензивне агротехничке мере, како основне и допунске обраде земљишта, тако и мере неге. Услед раширености проблема корова, потребно је често применити хербициде у више наврата и у дужем временском периоду.

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DISTRIBUTION AND HARMFULNESS OF FIELD DODDER (*CUSCUTA CAMPESTRIS* YUNCKER) AT SUGAR BEET FIELDS IN SLOVAKIA*

ABSTRACT: During 2002—2004, field surveys of *field dodder* (*Cuscuta campestris* Yuncker) in croplands were done in southwestern Slovakia. From among 150 localities surveyed, 80 were found infested by the *field dodder*. Within crop plants, *C. campestris* infested sugar beet (*Beta vulgaris*), alfalfa (*Medicago sativa*), tobacco (*Nicotiana tabacum*), potato (*Solanum tuberosum*), lentil (*Lens esculenta*), parsley (*Pastinaca sativa*) and onion (*Allium cepa*). Besides the crops, 18 weed species were also recorded. The species from the genus *Polygonum* (*Polygonaceae*) were the most important and acted as a significant reservoir of *field dodder* in cropland. *C. campestris* was not found in cold climatic regions with altitude higher than 240 m.

The impact of *field dodder* infestation on sugar beet yield was studied during the year of 2004 in two localities (Šalov and Žitavce) in southwestern Slovakia. The presence of *field dodder* markedly reduced both, quantity and quality of sugar beet yield. Weight of heavily infested beets was reduced from 21.6 to 37.4% and sugar content from 12.0 to 15.2%. Such decline of both parameters was also recorded when *field dodder* was removed together with leaves of sugar beet during growing season at the end of July. The aim of the infested leaves removal was to decrease mass of *field dodder* seeds. Although the leaf area of sugar beet regenerates, the decrease of quality and quantity was observed. The decline was the same at both localities, no matter whether the fields were irrigated (Šalov) or not (Žitavce).

KEY WORDS: *Beta vulgaris*, *Cuscuta campestris*, dodder, infested leaf removal, sugar content reduction, yield losses

INTRODUCTION

Field dodder (*Cuscuta campestris*) is an annual holoparasitic stem parasite in the family *Cuscutaceae* with leafless, thread-like, orange or yellow stems that twine over other plants. The species was introduced from North America to Europe in 1883 (Jehlík, 1998). *C. campestris* was found on 85 host plant

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species, including sugar beet, alfalfa, potato, tomato, onion and other vegetable crops (E r d ö s, 1971, N e m l i, 1986) but not grasses (D a w s o n et al., 1994). In addition, dodder seed is difficult to exclude from commercial alfalfa, clover, or flax seed (P a r k e r and R i c h e s, 1993).

Detailed data on the basic biology of *C. campestris* are reported by C o o k e and B l a c k (1987), M a l i k and S i n g h (1979) and V i s s e r (1985).

There is no evidence that *Cuscuta* spp. does not injure crop plants by producing allelochemicals, nor does *Cuscuta* spp. compete with crop plants in gathering environmental resources. The interference of *Cuscuta* spp. with crop plants is entirely by parasitism. The crop gathers resources and elaborates them into organic substances. The parasitic *Cuscuta* spp. then diverts the elaborated products (e.g. sugar) as well as basic resources (water and minerals) to itself. Parasitism by *Cuscuta* spp. can suppress the host plant severely (D a w - s o n et al., 1994). *Field dodder* can also transmit various viruses (G a r a u et al., 1993, K u m a r and M o h a n, 1994) and mycoplasma-like organisms (C r e d i and S a n t u c c i, 1992, V i c z i a n et al., 1998).

Intensity and severity of *C. campestris* attack on sugar beet highly depends on the effect of mineral nutrition (NPK fertilization). Lower rates of inadequate ratio of minerals, particularly in dry years are responsible for increases in *C. campestris* infection (S t o j š i n et al., 1991). *C. campestris* parasitizing sugar beet inhibits the growth of the host plant and reduces the content of sugars in leaves, petioles and roots, also altering the ratio of various sugars present (E v t u s h e n k o et al., 1973). Besides, the *field dodder* infestation on sugar beet slightly reduces K and Na contents and slightly increases Ca and Mg contents of the host plant (C h e p k a s o v a, 1973). The study of photosynthetic pigments in leaves of dodder-infested sugar beet plants showed that sugar beet plants intensively synthesized pigments, especially chlorophyll, in the early stages of infestation. As parasitization progressed, the pigment content of host plants declined and photosynthesis decreased (K a r a k e e v a, 1973).

The objectives of this research were to investigate the distribution and harmfulness of *field dodder* at sugar beet fields in Slovakia in order to find out more about an emerging threat for sugar beet and other field crops.

MATERIAL AND METHODS

During the growing seasons 2002—2004, the occurrence of *Cuscuta* spp. was observed in the agroecosystems of Slovakia following the natural phenology of dodders. 150 localities were chosen in different geographic and climatic regions. Collections were made depending on the amount of variation in the geography. Collecting sites were grassy or weedy roadsides, fallow fields and *Cuscuta* spp. — infested croplands planted with various crops. At each locality, plants were identified. Identification was based on the flower structure.

The impact of *field dodder*, *C. campestris*, infestation on sugar beet yield and quality was studied during 2004 in two commercial sugar beet fields in southwestern Slovakia, Šalov (48°01'N 18°48'E, 178 m a. s. l., field was irrigated) and Žitavce (48°12'N 18°18'E, 141 m a. s. l., no irrigation present). The samples were taken during September at both locations. The samples consisted of 25 sugar beet plants infested by *field dodder*, 25 plants without infestation and 25 plants with recovered leaf area after the infestation removal. The samples were selected at random within *field dodder* infested and uninfected sugar beet plants. Sugar beet roots were topped, placed in bags and transported to the sugar refinery Eastern Sugar Dunajská Streda for analyses. The percentage of sucrose and quality analyses were determined by the Eastern Sugar laboratory using standard industry procedures.

RESULTS

Altogether, four species of dodders were found on 150 different localities in agroecosystems of Slovakia, *C. campestris*, *C. epithymum*, *C. europaea* and *C. lupuliformis*. From among 150 localities surveyed, 80 were infested by *field dodder* (*C. campestris*). The complete view of localities infested by *field dodder* is given in Figure 1. Within crop plants, *C. campestris* infested sugar beet (*Beta vulgaris* prov. *altissima*), alfalfa (*Medicago sativa*), tobacco (*Nicotiana tabacum*), potato (*Solanum tuberosum*), lentil (*Lens esculenta*), parsley (*Pastinaca sativa*) and onion (*Allium cepa*) in Slovakia. Besides the crops, 18 weed species were also recorded. The species from the genus *Polygonum* (*Polygonaceae*) were the most important. *C. campestris* was not found in cold climatic regions with altitude higher than 240 m. In Slovakia, the only locations with regular infestation of sugar beet by *field dodder* (these are marked with white dots in Figure 1) were Abrahám (48°15'N 17°37'E, 125 m a. s. l.), Iňa (48°11'N 18°30'E, 180 m a. s. l.), Šalov (48°01'N 18°48'E, 178 m a. s. l.), Veľký Cetín (48°13'N 18°12'E, 137 m a. s. l.) and Žitavce (48°12'N 18°18'E, 141 m a. s. l.).

At both locations observed (Šalov, Žitavce) for the impact of *field dodder* on sugar beet, dodder infestation reduced weight and sugar content (Table 1 and 2). At Žitavce, weight of 25 beets, taken from dodder-infested plants was reduced by 4 kg (37.4% reduction) and sugar content by 2.2% (12% reduction). At Šalov, weight of 25 beets, taken from infested plants was reduced by 2.7 kg (21.6% reduction) and sugar content by 2.4% (12.7% reduction). The reduction was slightly lower (except of sugar content at Šalov) in beets taken from plants where leaf area recovered after the infestation and dodder removal. In this case, weight of 25 beets was reduced by 1.9 kg (17.4% reduction) and sugar content by 2% (11.4% reduction) at Žitavce and by 2 kg of weight (15.6% reduction) and by 2.9% of sugar content (15.2% reduction) at Šalov. The decline was the same at both localities, no matter whether the fields were irrigated (Šalov) or not (Žitavce).

DISCUSSION

Of the four dodder species recorded at Slovakian croplands, only *C. campestris* and *C. epithymum* were regularly found throughout south of Slovakia.

C. campestris never exceeded 240 m a. s. l. and was found exclusively at the warmest localities of Slovakia, with maximum occurrence in the western part of state (Figure 1). From the literature, it is known that 85 various crop plants and weeds serve as hosts for *C. campestris* (E r d ö s, 1971), our findings show that in Slovakia, crops parasitized by this species included only potato (*Solanum tuberosum* L.), sugar beet (*Beta vulgaris* L.), alfalfa (*Medicago sativa* L.), lentils (*Lens esculenta*), tobacco (*Nicotiana tabacum* L.), parsley (*Pastinaca sativa*) and onion (*Allium cepa*). In addition, other 18 plants were found as hosts for *C. campestris*. Within these hosts, *Polygonum* spp. was the most common one occurring on 44 out of 47 localities observed. It acted as a significant reservoir of *field dodder* in cropland. Similarly J e h l í k et al. (1998) cited *Polygonum arenastrum*, *Artemisia vulgaris* and *Atriplex tatarica* like dominant hosts of *C. campestris* in Slovakia. The only problematic species are *C. campestris* and *C. epithymum* in the agroecosystems of Slovakia. While *C. epithymum* has already been infesting huge amount of alfalfa fields throughout the state, hitherto *C. campestris* has been damaging crops at the warmest localities exclusively. On the other hand, there is a big potential of *C. campestris* to spread into agricultural crops. The reasons for such spread are different. Above all: 1) the great distribution of the main host plant (*Polygonum* spp.) throughout Slovakia and very low host specificity, 2) limited number of natural enemies of *C. campestris* expected (because it is an invasive plant) in order to suppress population density and 3) expected warming, which can make the species more aggressive.

Field dodder reduces the average weight of sugar beet roots and foliage and reduces the sugar content, total N, invert sugar and ash contents of roots and increases the content of pectin substances (K a r a k e e v a, 1973). The presence of *field dodder* markedly reduced both, quantity and quality of sugar beet yield in Slovakia. Weight of heavily infested sugar beet roots was reduced from 21.6 to 37.4%. Similarly, L u k o v i n and K i t e n k o (1974) noted sugar beet root yields reduction up to 50% in Kyrgyzstan. Of the studies that have been done to determine the impact of *field dodder* on sugar content, there were similar results regarding actual sucrose losses. For example, K a r a k e e v a (1973) observed 1—2.6% sugar reduction and B e l y a e v a et al. (1978) reported reduction in the sugar content by 1.5—1.9% and the sugar yield by 3.5—4 t/ha, both in Kyrgyzstan. Sugar content reduction ranges from 2.2—2.4% (i.e. 12.0—12.7% of sugar yield reduction) in Slovakia. Such decline of both parameters was also recorded when *field dodder* was removed together with leaves of sugar beet during growing season at the end of July. The aim of the infested leaves removal was to decrease mass of *field dodder* seeds. Although, the leaf area of sugar beet regenerates, the slight decrease of quality and quantity was observed (Table 1. and 2).

Table 1. Gross yield and sugar content of sugar beet infested by *field dodder*, *Cuscuta campestris*, at location Šalov. Results are based on samples of 25 sugar beets taken on September 27, 2004

Sugar beet plants	Weight/kg	Beet tops/kg	Sugar content/%*
Non-infested with field dodder	12,71	5,04	19,03
Infested with field dodder	9,96	7,43	16,61
Leaf area recovered after the infestation removal	10,73	5,43	16,14

* Laboratory tests, the percentage of sucrose and quality analyses were determined by sugar refinery, Eastern Sugar Dunajská Streda using standard industry procedures

Table 2. Gross yield and sugar content of sugar beet infested by *field dodder*, *Cuscuta campestris*, at location Žitavce. Results are based on samples of 25 sugar beets taken on September 22, 2004

Sugar beet plants	Weight/kg	Beet tops/kg	Sugar content/%*
Non-infested with field dodder	10,81	3,10	18,10
Infested with field dodder	6,77	4,93	15,92
Leaf area recovered after the infestation removal	8,93	3,28	16,03

* Laboratory tests, the percentage of sucrose and quality analyses were determined by sugar refinery, Eastern Sugar Dunajská Streda using standard industry procedures

The severity of infestation depends on the growth stage of the host plant at the time of initial dodder attachment. The greatest growth reduction occurs when dodder attaches to sugar beet plants very early. Although established host plants are usually not killed by dodder infestation, reduction of both, quantity and quality of sugar beet will occur. When multiple attachments are made to the same host plant (already established), death can occur as we found in the case of sugar beet in Slovakia. The weakened state of infected plants also predisposes them to losses caused by other pests such as diseases, insect and nematode invasions (Cudney et al., 1992).

There are many options available to help decrease the crop infestations by dodders such as hand cultivation, spot or field burning, close mowing, later planting time and crop rotation with cereals or corn (Dawson et al., 1994). Within chemical control, interesting results were obtained using maleic hydrazide at 7 kg/ha + wetter 0.5% applied at the flowering stage of dodder. The procedure reduced the foliage of the parasite by 74—88%, the germination of surviving malformed seeds was reduced to less than 25% and thus, seed reserves in the soil were decreased (Belyaeva et al., 1978). On the other hand, biological control is particularly attractive means of suppressing *field dodder* in crop because, owing to its intimate relationship with the host plant, it is difficult to apply chemical herbicides in such a way the crop is not adversely affected (CAB, 1987). Hence, it is surprising that little effort has been made to achieve biological control of these weeds worldwide, so the search for biological control agents therefore seems to be warranted.

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РАСПРОСТРАЊЕНОСТ И ШТЕТНОСТ КРУПНОЗРНЕ КОСИЦЕ, *CUSCUTA CAMPESTRIS* Y U N C K E R, У УСЕВИМА ШЕЋЕРНЕ РЕПЕ У СЛОВАЧКОЈ

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Резиме

Током 2003. и 2004. године праћена је распрострањеност крупнозрне виline косице (*Cuscuta campestris* Y u n c k e r) у агроекосистемима у Словачкој. *C. campestris* је била констатована на 80 локалитета у разним деловима Словачке на следећим биљкама домаћинима из групе гајених биљака: шећерна репа (*Beta vulgaris* prov. *altissima*), луцерка (*Medicago sativa*), дуван (*Nicotiana tabacum*), кромпир (*Solanum tuberosum*) и першун (*Pastinaca sativa*). Осим на културним биљкама крупнозрна вилина косица је констатована и на 18 врста корова, од којих су најважније врсте из рода *Polygonum* (*Polygonaceae*), који представља значајан резервоар ове врсте вилине косице у агроекосистемима. *C. campestris* није била констатована у хладнијим климатским подручјима на надморској висини изнад 240 m.

Анализирали смо и утицај крупнозрне вилине косице на висину приноса и квалитет шећерне репе на два локалитета југозападне Словачке (Шалов и Житавце). Присуство крупнозрне вилине косице имало је утицај не само на висину приноса него и на квалитет шећерне репе на оба локалитета. Тежина корена нападнутих биљака била је нижа од 12,7 до 22,0% у поређењу са ненападнутима, а садржај шећера је у нападнутим биљкама био нижи од 12,5 до 37,4%. До снижења оба параметра долазило је и у ситуацији када је у току вегетације (крајем јула) одстрањена вилина косица заједно са лишћем шећерне репе. Циљ ове мере је био снижење продукције семена вилине косице. Лисна маса се регенерисала, али снижење квантитета и квалитета приноса није заустављено. Разлика у снижењу квалитета и квантитета приноса није било ни између биљака које су биле заливане (Шалов) и биљака са парцела из сувог ратарења (Житавце).

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FORECASTING OF MAJOR SUGAR BEET PEST OCCURRENCE IN SERBIA DURING THE PERIOD 1961—2004*

ABSTRACT: In Serbia, sugar beet is grown in the province of Vojvodina mostly. The increase in areas sown to this crop in the province from 30,000 hectares in 1931—1939 to over 70,000 in 1951—2000 provided a large boost to the reproduction of sugar beet pests in this part of the country. More than 15 species are considered major pests of sugar beet. The Department of Plant and Environmental Protection of the Faculty of Agriculture in Novi Sad and the Institute of Field and Vegetable Crops in Novi Sad have been making forecasts of the occurrence of major sugar beet pests since 1961. Over the last 30 years (1975—2004), the following average pest numbers per meter square at the end of the growing season have been recorded: *Bothynoderes punctiventris* (3.3), *Elateridae* (3.6), *Melolonthidae* (1.0), *Scotia* spp. (0.4), *Mamestra* spp. (1.5) and *Scrobipalpa ocellatella* (14.8). In addition to these, population dynamics of the following pest species are also monitored: *Lixus scabricollis*, *Chaetocnema tibialis*, *Cassida* spp., *Aphis fabae*, *Pemphigus fuscicornis*, *Autographa gamma* and *Loxostege sticticalis*.

KEY WORDS: sugar beet, pests, population dynamics, forecasts of occurrence

INTRODUCTION

Sugar beet is important crop in Serbia, mainly grown in the province of Vojvodina (northern part of the country). Areas sown to sugar beet in the province varied over the years as follows: 30.000 ha (1930—1939), 43.000 ha (1947—1960), 45.000 ha (1961—1970), 68.000 (1971—1980) and 86.000 ha (1981—1990). At the end of the 20th century, the acreage under this crop significantly decreased.

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The acreage in sugar beet increased greatly in the second half of the 20th century compared with the first and sugar beet growing became concentrated in large agricultural estates. This promoted the multiplying of numerous pest species and enhanced their agricultural importance. There are over 15 pest species or pest groups that are considered major pests of sugar beet (Č a m p r a g, 1992). These include *Bothynoderes punctiventris* G e r m., *Tanymecus dilaticollis* G y l l., *Chaetocnema tibialis* I l l i g., *Elateridae* (*Agriotes* spp.), *Melolonthidae, Euxoa temera* H b., *Scotia segetum* S c h i f f., *S. ipsilon* H u f n., *Mamestra brassicae* L., *Scrobipalpa ocellatella* B o y d., *Loxostege sticticalis* L., *Aphis fabae* S c o p., *Pemphigus fuscicornis* K o c h., *Heterodera schachtii* S c h m i d t., *Microtus arvalis* P a l l. and *Cricetus cricetus* L.

MATERIALS AND METHODS

In 1961, the research began in Vojvodina on the long- and short-term predictions of the severity of occurrence of major sugar beet pests in the province in order to reduce losses caused by them, make the crop protection more economical and reduce agroecosystem and environmental pollution by pesticides. This effort, headed by the Department for Plant and Environmental Protection of the Faculty of Agriculture in Novi Sad has been ongoing for the past 45 years and is carried out in collaboration with 13 regional agricultural organizations (institutes, departments and stations) and several major agricultural cooperations. It produces exact long-term predictions for *B. punctiventris, Elateridae*, and *Melolonthidae* and more approximate long-term predictions for *S. segetum, M. brassicae* and *S. ocellatella*. Data for these prognoses are collected during September/October by examining soil sown to sugar beet as well as that on which wheat, the most common preceding crop in sugar beet production was previously grown. In the last 45 years, on average, around 75 fields sown to sugar beet and around 100 of those on which wheat was the last crop have been examined annually. The samples have been collected using probes 0.25 m^2 in size (50 x 50 cm and up to 50 cm deep).

The dynamics of *S. ocellatella* incidence was determined by examining the total of 100 sugar beets in late September (10 locations were inspected overall and 10 plants were taken from each). The same method was also used during the growing season to monitor population dynamics and frequency of occurrence of most of other major sugar beet pests in order to make short-term predictions of their incidence.

RESULTS AND DISCUSSION

Table 1. shows population dynamics by year of six pest species or pest groups (of the families *Coleoptera* and *Lepidoptera*) during 1975—2004. In that period, it often happened that in years in which the incidence of the species *B. punctiventris* and *S. ocellatella* was high, that of the species of the *Ma-*

mestra genus was low and vice versa. The former two species are xerothermophilous, while the latter are hygrophilous and do not like high temperatures.

Table 1. Population dynamics of major pests of sugar beet in Vojvodina during 1975—2004.

Year	Pest density (No. per 1 m^2)					
	Bothynoderes punctiventris	*Elateridae*	*Melolonthidae*	*Scotia* spp.	*Mamestra* spp.	*Scrobipalpa ocellatella*
1975	0.0	5.5	0.6	0.60	7.8	0.0
1976	1.6	2.6	0.6	1.10	2.6	2.4
1977	0.0	3.9	0.8	0.30	0.4	1.6
1978	0.1	4.6	0.5	0.30	14.0	1.6
1979	0.0	5.0	0.4	0.70	4.0	4.0
1980	1.1	3.9	0.3	0.20	3.5	6.4
1981	3.6	7.1	0.7	0.48	0.4	3.2
1982	8.0	8.2	1.5	0.63	1.7	4.0
1983	9.8	6.8	0.9	0.50	0.3	40.0
1984	15.5	3.2	0.9	0.25	1.0	21.6
1985	6.3	5.2	1.0	0.39	4.1	8.8
1986	1.9	4.6	1.3	0.17	0.3	35.2
1987	2.1	3.7	1.0	1.20	1.0	26.4
1988	5.2	2.1	0.5	0.13	0.3	74.4
1989	2.1	4.2	1.2	0.94	0.4	4.8
1990	1.8	1.3	0.4	0.19	1.4	9.6
1991	5.7	1.8	1.0	1.00	1.3	6.4
1992	3.6	1.0	2.9	0.38	0.1	38.4
1993	5.3	0.7	1.4	0.05	0.0	12.8
1994	7.5	3.5	2.5	0.03	0.1	22.4
1995	2.4	1.2	0.6	0.23	0.5	4.0
1996	1.1	3.6	1.0	0.28	0.2	2.4
1997	0.7	2.1	0.3	0.16	2.6	0.8
1998	0.6	4.0	0.9	0.61	0.1	4.0
1999	2.1	4.3	0.8	0.64	0.4	0.0
2000	1.0	1.7	1.2	0.04	0.0	25.6
2001	2.9	3.6	1.4	0.13	0.0	3.2
2002	1.3	4.9	2.9	0.22	0.2	10.4
2003	3.9	2.0	1.0	0.13	0.0	36.8
2004	1.0	3.1	0.4	0.13	0.2	?
Average	3.3	3.6	1.0	0.39	1.5	14.8

Shown in Table 2. are data on the percentage contributions of different levels of infestation by *B. punctiventris, Mamestra* spp. and *Elateridae* on fields in years with high and low incidences of these pests. In years with low abundance of the overwintering individuals of these species, a prediction was made in the autumn that their incidence would be low the following spring, which made it possible to make major savings in the area of chemical crop protection.

Bothynoderes punctiventris G e r m. This species is the most important pest of sugar beet in Vojvodina. Over the last 60 years, it has destroyed more than 250,000 hectares of young sugar beets in total and has caused crops to be resown. Between 1961 and 2003, 3.1 individuals were recorded per meter square on average (Č a m p r a g, S e k u l i ć et al., 2004). By the end of the decade, the average varied as follows: 3.5 (1961—1970), 0.6 (1971—1980), 5.6 (1981—1990) and 3.0 (1991—2000).

The abundance of *B. punctiventris* in the last 30 years is shown in Table 1. It varied from 0 to 15.5 m^2 depending on the year. Mass reproduction of the insect is favored by higher temperatures and drought during the growing season, especially when there are two to three such years in succession. Based on the number of overwintering individuals, a long-term prognosis is made in autumn in order to estimate the level of danger from this pest for the following year. The level of risk in 1979 was much lower than that in 1984 (Table 2).

Table 2. Different possibilities for making savings in sugar beet pest control by forecasting

Number per m^2	Percentage contribution of fields with different pests density			
	Bothynoderes punctiventris		*Mamestra* spp.	
	1979	1984	1963	1965
0	**81**	1	**57**	1
0.1—1	19	5	**34**	5
1.1—5	0	35	9	17
5.1—10	0	**22**	0	**22**
10.1—20	0	**12**	0	**29**
> 20	0	**25**	0	**26**
Total	100%	100%	100%	100%
Average density/m^2	**0.1**	**15.5**	**0.3**	**18.6**

Elateridae. After the cultivation of wheat, which is most often followed by sugar beet, around 20 click beetle species were found in the Vojvodina province. The dominant pests are the larvae of *Agriotes ustulatus* S c h a l l., followed by *A. sputator* L. and other species. *Agriotes* genus accounts for 79% of all click beetle individuals found in the province and for 76% of those found in Ukraine (F e d o r e n k o, 1998). Over a 30-year period, the average number of the larvae recorded per meter square was 3.6, ranging from 0.7 to 8.2/m^2 depending on the year (Table 1). During the 1961—2003 period, the average number was 3.3/m^2.

Chemical control of click beetle larvae should be performed when their incidence exceeds the economic damage threshold of one individual per meter square. Many sugar beet growers incorporate insecticides into the soil preventatively without inspecting the field for larval abundance beforehand and thus unnecessarily increase their production costs. The larval abundance per meter square varies widely from field to field and from year to year, as illustrated by

Table 2. Larger savings could have been made on the chemical control of click beetle larvae in 1993 than in 1982.

Melolonthidae. The soil on fields sown to sugar beet is dominated by the larvae of the following three species: *Anisoplia austriaca* H r b s t., *Rhizotrogus aequinoctialis* H r b s t. and *Amphimallon solstitialis* L. Population dynamics of the entire family during 1975—2004 are presented in Table 1. The annual incidence ranged from 0.3 to 2.9 m^2, averaging 1.0. The best conditions for the reproduction of *A. austriaca* in Vojvodina existed during the 1992—1994 period, when the average abundance of the species was 2.3/m^2. Larvae of *A. austriaca* account for 65% of all *Melolonthidae* larvae present in Vojvodina and for 58% of those reported in neighbouring Hungary (M a n n i n g e r, 1955).

Scotia spp. In Vojvodina, *S. segetum* S c h i f f. species is highly dominant, while *S. ipsilon* H u f n. is second in importance. The abundance of the second generation caterpillars ranged between 0.03 and 1.2/m^2 during 1975—2004 (Table 1). On average, 0.4 larvae per meter square were recorded. The same average was recorded in Hungary between 1955 and 1964.

In the last six decades, there were three massive outbreaks of *S. segetum* in Hungary, in 1948—1950, 1962 and 1968 (M é s z á r o s, 1993). Such outbreaks were recorded in the same years in Vojvodina as well. In the past 36 years, however, there was no major, widespread outbreak of this pest in the province.

Euxoa temera H b. This species is a dangerous polyphagous pest that causes major damage to sugar beet crops from time to time. The last huge outbreak of this insect in the region was recorded back in 1946—1950 in Serbia, Bulgaria and Hungary. In 1948 in Bulgaria, the pest completely destroyed about 7,200 hectares of young sugar beet, which represented one third of the total acreage sown to this crop in the country that year.

For over half a century, there has been no mass reproduction of *E. temera* in the above countries. The last mass outbreak of huge proportions mentioned above was caused by drought and high temperatures that lasted several years. In the 20th century, the average growing season temperature in Belgrade was 18.5°C. The hottest five-year stretch during that 100-year period was the time between 1946 and 1950, when the average temperature during the growing season was 19.9°C and frequent droughts occurred, causing the afore-mentioned massive outbreak of *E. temera.* There has been no repeat of such conditions since 1951. Short-term predictions of *E. temera* occurrence in Serbia are made by monitoring the flight dynamics of the butterflies during August/September using light traps.

Mamestra spp. There are two *Mamestra* species that are important for Serbian sugar beet production, namely *M. brassicae* and *M. oleracea*. The former species is of particular importance, because it accounts for 80% of all individuals of this genus found in the country, while the remaining 20% belong to the latter species. The same ratio is found in neighbouring Hungary (M é s z á r o s, 1993). A single caterpillar of the cabbage moth consumes a total of 169 cm^2, or 5.8 g of sugar beet leaves in the course of its life (S e k u l i ć, 1972).

During 1961—2003, an average of 2.8 individuals per meter square was recorded in the country for the second generation (Č a m p r a g, S e k u l i ć et al., 2004). Depending on the decade, this average varied as follows: 5.9 (1960s), 6.5 (1970s), 1.1 (1980s) and 0.5 (1990s). Table 1 shows cabbage moth abundance by years over the last 30 years. Between 1961 and 2004, the incidence of this pest ranged from 0 to 18.6/m^2 and was the highest in 1965.

Mass reproduction of the cabbage moth is favored by wetter growing season conditions (i.e. wetter microclimate of sugar beet crop) with no high temperatures. This insect was not on the list of sugar beet pests in Croatia in 1930s, when average yields of around 20 t/ha were obtained (K o v a č e v i ć, 1931). It became major sugar beet pest in Serbia and Croatia because of intensified production (use of higher-yielding varieties, higher nitrogen fertilizer rates and irrigation) and the development of luxuriant sugar beet plants as well as of the use of dense and complete stands in sugar beet production. The insect is found in fields that produce high yields and is absent from those where the crops are in poor condition. For example:

1930—1939 = 19 t/ha on average (no major presence of the pest)

1961—1980 = 38 t/ha on average (mass reproduction of the pest)

Rough long-term predictions for the cabbage moth are made based on the abundance of the insect overwintering pupae. Very different levels of infestation were predicted in the autumn of 1963 and 1965 for the first generation in the following year (Table 2).

In our country, the flight dynamics of cabbage moth butterflies are monitored using light traps. The butterfly abundance determines the level of infestation by the catterpillars and the extent of the need for crop protection. In Vojvodina, 345—393 butterflies were caught for three consecutive years (1978—1980) and 13,000 hectares of sugar beet were treated on average. In the following year, 1981, 105 butterflies were caught and 2,950 hectares were treated.

Scrobipalpa ocellatella B o y d. This species reproduces on a mass scale occasionally, when there is dry and warm weather during the growing season. Weather conditions, especially during July and August, play the dominant role in the population dynamics of this pest (S t a n k o v i ć, 1954). In Vojvodina, mass outbreaks were recorded in 1949—1950, 1962—1964 and in several years during the 1983—1994 period.

Between 1975 and 2003, about 15 catterpillars per meter square were recorded at the end of the growing season on average, ranging from 0 in 1999 to 74 in 1988 (Table 1). In 1988, the year with peak incidence of the pest, the population dynamics were as follows: June 7—10% of the fields infested (1% of sugar beet plants attacked), June 23—70% (4%), July 13—90% (14%), July 28—100% (26%), August 8—100% (65%) and September 29—100% (92%).

For prediction-making purposes, the abundance and frequency of occurrence of the following sugar beet pests is monitored: *Lixus scabricollis* B o h., *Chaetocnema tibialis* I l l i g., *Cassida* spp., *Aphis fabae* S c o p., *Pemphigus fuscicornis* K o c h. and so on.

The long- and short-term predictions of the occurrence of sugar beet pests are presented to the public in various ways (at crop protection seminars and consultations, at consultation meetings of agronomists, by publication in the journal Plant Doctor or in agricultural magazines such as the Farmer and others).

The economic damage thresholds for some of the sugar beet pest species are as follows: *Elateridae* (over 1 individual per meter square), *Amphimallon* and *Rhizotrogus* spp. (2—3 ind./m^2), *Bothynoderes punctiventris* (0.1—0.3 ind./m^2 for seedlings*), Euxoa temera* (0.3—1 ind./m^2), *Scotia ipsilon* (1—2 ind./m^2), *S. segetum* (2—3 ind./m^2), and *Mamestra* spp. (8—10 ind./m^2).

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ПРОГНОЗИРАЊЕ ПОЈАВЕ ШТЕТОЧИНА ШЕЋЕРНЕ РЕПЕ У СРБИЈИ У ПЕРИОДУ 1961—2004. ГОДИНА

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Резиме

Шећерна репа се у Србији углавном гаји у покрајини Војводини. Повећање површина у Војводини са 30.000 хектара (1931—1939) на преко 70.000 (1951—2000), веома је погодовало повећању размножавања штеточина шећерне репе. Томе је допринела и концентрација производње на крупним газдинствима. У важније штеточине ове културе убраја се преко 15 врста. Департман за заштиту биља и животне средине (Пољопривредног факултета у Новом Саду) и Научни институт за ратарство и повртарство од 1961. баве се прогнозирањем појаве важнијих штеточина шећерне репе. То се обавља у сарадњи са 13 регионалних установа пољопривредне службе и са неколико пољопривредних комбината. Током 30 година (1975—2004) установљена је крајем вегетације просечна бројност по m^2 следећих штеточина: *Bothynoderes punctiventris* (3,3), *Elateridae* (3,6), *Melolonthidae* (1,0), *Scotia* spp. (0,4), *Mamestra* spp. (1,5) и *Scrobipalpa ocellatella* (14,8). У годинама када је бројност репине пипе и репиног мољца висока, најчешће бројност купусне совице буде ниска, као и обратно. Поред наведених штеточина, прати се кретање бројности и учесталости сретања *Lixus scabricollis*, *Chaetocnema tibialis*, *Cassida* spp., *Aphis fabae*, *Pemphigus fuscicornis*, *Autographa gamma* и *Loxostege sticticalis*.

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CONTROL OF SUGAR BEET PESTS AT EARLY SEASON BY SEED TREATMENT WITH INSECTICIDES*

ABSTRACT: In the period 2001—2004, experiments were conducted in the region of Bačka (northern Serbia) to assess the efficiency of insecticide treatment of sugar beet seeds in controlling soil pests (larvae of *Elateridae* family) and reducing the damage caused by beet weevil (*Bothynoderes punctiventris* Germ.) and flea beetle (*Chaetocnema tibialis* Illig.). Several insecticides, mostly systemic ones (carbofuran, thiamethoxam, fipronil, imidacloprid and clothianidin), and their combinations with pyrethroids in different doses were tested in field conditions. Stand density, percentages of plants damaged by *B. punctiventris* and *C. tibialis*, injury level and weight of juvenile plants served as parameters for evaluation of insecticide efficiency. Most of the insecticides applied to seeds provided a significantly better stand density compared with the untreated control. Because of their systemic action, imidacloprid, thiamethoxam and their mixtures with pyrethroids provided very good protection of juvenile plants from *C. tibialis* and in some cases from *B. punctiventris*.

KEY WORDS: sugar beet, insecticides, seed treatment, wireworms (*Elateridae*), sugar beet weevil (*Bothynoderes punctiventris* Germ.), flea beetle (*Chaetocnema tibialis* Illig.)

INTRODUCTION

Under the conditions of southeastern Europe including our country, a large number of harmful insects occur during initial stages of sugar beet development (from germination and emergence to the development of 2—4 pairs of permanent leaves). Their occurrence is the key factor of stability in sugar beet production. Among the pests of underground plant parts, click beetle and cha-

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fer larvae (*Elateridae* and *Scarabaeidae* families) are distinguished for their economic importance. For last ten or so years in Serbia, soil pests, primarily wireworms have been controlled at about 80% of a total sugar beet acreage of about 60,000 hectares. Newly emerged sugar beet crops are threatened by numerous coleopterans, especially beet weevil (*Bothynoderes punctiventris* G e r m.), weevil (*Psalidium maxillosum* F.), gray corn weevil (*Tanymecus dilaticollis* G y l l.), flea beetle (*Chaetocnema tibialis* I l l i g.) and other species that occurred in some years. These pests are frequently the cause of thin crop stands and replanting at large areas (Č a m p r a g, 2000).

In spite of attempts to introduce integrated management of the above mentioned pests, which implies the combining of all available measures in time and space (agrotechnical, mechanical, biological etc.), chemical measures still hold the dominant place. However, more and more stringent requirements regarding the economy of crop production and environmental protection impose the need of introducing less costly and ecologically more selective methods of insecticide application, such as seed treatment during processing or before planting.

This paper reviews the results of experiments undertaken to assess the efficiency of sugar beet seed insecticide treatment in the control of wireworms (the larvae of *Elateridae* family), beet weevil (*Bothynoderes punctiventris*) and flea beetle (*Chaetocnema tibialis*).

MATERIAL AND METHOD

In the period 2001—2004, in several locations in the region of Bačka (northern Serbia), on the calcareous chernozem soil, we assessed the efficiency of seed treatment with insecticides in controlling soil pests and pests that attack sugar beets at the beginning of growing season. Sugar beet seed treatment (mostly encrusted seeds, except for 2003, when pelleted seeds were used) was performed immediately before planting, in the seed processing facilities of Institute of Field and Vegetable Crops in Novi Sad.

The experiments included the following insecticides: thiamethoxam (at the doses of 2 l/100 kg of seeds and 15, 20, 30, 45 and 60 g active substance (a.s.)/seed unit (s.u.), imidacloprid (at the doses of 25, 50 and 90 g a.s./s.u.), fipronil (at the doses of 80 and 100 ml a.s./s.u.), carbofuran (at the doses of 30 g a.s./s.u. and 3 and 4 l/100 kg seeds), tefluthrin (at the doses of 8 g a.s./s.u. and 5.0 kg/ha) and clothianidin (at the dose of 68 g a.s./s.u.), the mixtures thiamethoxam + tefluthrin (15 + 6, 15 + 8, 60 + 4 and 60 + 8 g/s.u.), imidacloprid + beta-cyfluthrin (15 + 8, 45 + 6 and 60 + 8 g a.s./s.u.), imidacloprid + tefluthrin (15 + 4 g a.s./s.u.), imidacloprid + pencycuron (100 ml a.s./s.u.), carbofuran + bifenthrin (2.0 + 0.2 l/100 kg seeds) and a granulated insecticide terbufos (at the dose of 25 kg/ha).

The experiments were conducted in the field, usually in small plot trials (large plot trials were used only in the first two years in the location of Kljajićevo), in a block design with four replications, with the basic experimental unit size of 20—30 m² (4—6 rows 8—10 meters long). The experiment plots were mostly machine-planted (except in the location Aleksa Šantić, where planting was performed manually), at the optimum date (March 19—29), in the spacing from 50 x 6 cm to 50 x 18 cm (in different years and locations).

The efficiency of the applied insecticides was evaluated via the following parameters: the achieved stand density, percentages of plants damaged by *B. punctiventris* and *C. tibialis*, injury level caused by *C. tibialis* and weight of juvenile plants. The results were mostly expressed in relative values.

RESULTS

The effect of the tested insecticides varied depending on the pest population density and weather conditions during the study period.

The effect of seed treatment on soil pests and *B. punctiventris*. In the first year of study (2001), better protection of crop stand from the soil pests was achieved in the location A. Šantić than in the location Kljajićevo. The first location had a higher density of wireworm larvae from *Agriotes* genus than the second one (14.0/m^2 and 3.2/m^2, respectively). In A. Šantić, stand density was higher comparing to the control (in the second, final evaluation) from 15—19% in the case of thiamethoxam to 36—46% in the cases of imidacloprid and its mixtures with tefluthrin and beta-cyfluthrin (Table 1). The case was reversed with *B. punctiventris*. Its occurrence was lower in the first location (only 15.5% slightly damaged plants in the control) and the efficiency of insecticides was proportionally lower. In the location Kljajićevo, all control plants were intensively damaged by *B. punctiventris.* The lowest percentage of damaged plants (26—30%), with very low intensity of damage was achieved with thiamethoxam (60 g a.s./s.u.) and imidacloprid (90 g a.s./s.u.).

Table 1. The effects of seed treatments by insecticides against wireworms (*Elateridae*) and sugar beet weevil (*Bothynoderes punctiventris* G e r m.) in sugar beet crops, expressed through relative stand density and percentage of damaged plants in 2001

Active substance	Amount of active substance (g, ml/unit)	Relative crop stand (%)		Percentage of plants damaged[a)] by *B. punctiventris* (%)	
		A. Šantić	Kljajićevo	A. Šantić	Kljajićevo
Carbofuran	30	98.7	98.2	9.5	42.0*
Thiamethoxam	45	115.1	102.0	14.6	70.0*
Thiamethoxam	60	119.2	116.8	12.7	26.0
Imidacloprid	90	144.8	113.0	10.7	30.0
Imidacloprid + tefluthrin	15 + 4	146.1	99.3	14.7	94.0**
Imidacloprid + betacyfluthrin	15 + 8	136.5	—	7.1	—
Imidacloprid + betacyfluthrin	45 + 6	145.9	—	8.7	—
Imidacloprid + betacyfluthrin	60 + 8	143.1	—	9.9	—
Control	—	100.0	100.0	15.5	100.0***

[a)] Damage extent from *B. punctiventris*: — very low, * low, ** medium, *** high

In the second year of study (2002), although the density of wireworm larvae in the soil (6.0 and 8.4/m^2) was similar in the respective locations, results were similar to previous year regarding the maintenance of stand density and the degree of plant damage by *B. punctiventris* (Table 2). In the location A. Šantić, insecticides exhibited high efficiency regarding the control of soil pests, i.e. the maintenance of stand density, with the percentages from 18.6% in the case of carbofuran to about 31% in the cases of fipronil (100 ml/s.u.) and terbufos. The occurrence of *B. punctiventris* in that location was low (only 14.2% of slightly damaged plants in the control) and the activity of insecticides was modest. In the location Kljajićevo, the control had about 30% of plants slightly damaged by *B. punctiventris*. The lowest percentages of damaged plants (5—8%), together with low intensities of damage were achieved with the application of terbufos, thiamethoxam and fipronil (100 ml a.s./s.u.).

Table 2. The effect of seed treatments by insecticides against wireworms (*Elateridae*) and sugar beet weevil (*Bothynoderes punctiventris* Germ.) in sugar beet crops, expressed through relative stand density and percentage of damaged plants in 2002

Active substance	Amount of active substance (g, ml/unit)	Relative crop stand (%)		Percentage of plants damaged[a)] by *B. punctiventris* (%)	
		A. Šantić	Kljajićevo	A. Šantić	Kljajićevo
Carbofuran	3.0 l/100 kg seed	118.6	62.2	10.0	16.2
Thiamethoxam	2.0 l/100 kg seed	123.1	71.2	9.8	7.2
Fipronil	100	130.2	95.8	11.7	8.1
Fipronil	80	124.8	—	12.5	—
Imidacloprid + pencycuron	100	128.4	—	11.0	—
Terbufos	25.0 kg/ha	130.7	92.8	10.6	5.3
Control	—	118.6	100.0	14.2	29.6

a) Damage extent from *B. punctiventris*: A. Šantić — very low, Kljajićevo — low

In the third year of study (2003), in the conditions of an extremely dry spring, all preparations and mixtures exhibited highly positive effects regarding the protection of crop stand against soil pests in all three locations (Figure 1). The effect was the highest in A. Šantić, where the population density of wireworms was also the highest (14.7 individuals/m^2). Compared to the control, the stands were from 63% higher in the plots with mixture of imidacloprid and tefluthrin to 98—116% in the case of the mixtures of thiamethoxam and tefluthrin (the percentage increasing in proportion with the dose). In the location of Sombor (7.2 individuals/m^2) the stands were higher from 21% (tefluthrin) to 77% (thiamethoxam) in relation to the control. In the location R. Šančevi (6.3 individuals/m^2), the efficiency was somewhat lower than in the first two locations and it was at the same significance level as the treated crop stands in relation to the control and the stands were from 25% higher in the case of thiamethoxam to 34% in the case of the medium dose of the mixture of thiamethoxam and tefluthrin.

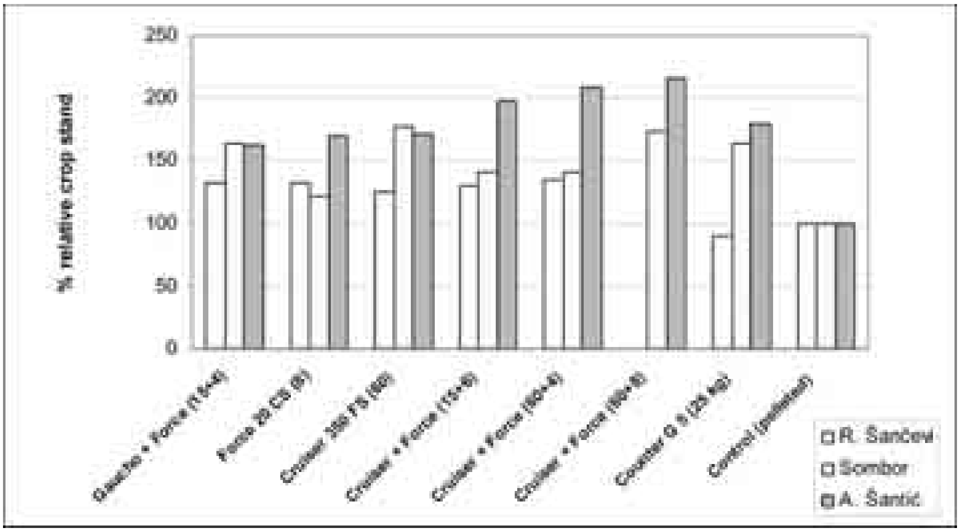

Fig. 1. The effect of seed treatment by insecticides against wireworms (*Elateridae*) in sugar beet crops, expressed through relative stand density in 2003

In the last year of study (2004), which was characterized by considerably lower density of the wireworm population in the soil and abundant rainfall in April and May, which postponed the emergence and growth of plants while accelerating the degradation and leaching of the applied insecticides, the efficiency of the insecticides in the protection of crop stand was much lower (Figure 2) than in the previous years, especially in the location of R. Šančevi. In the location A. Šantić, which had the highest density of wireworms (2.7 individu-

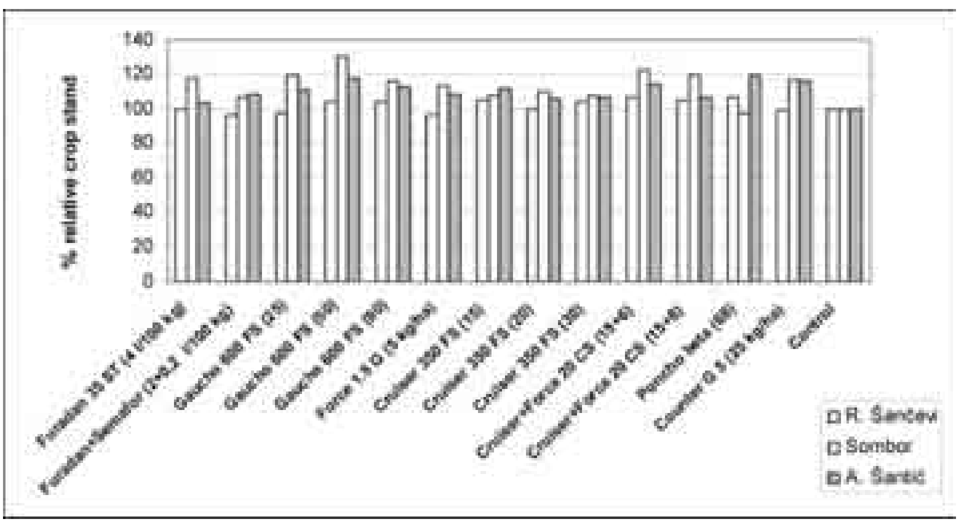

Fig. 2. The effect of seed treatment by insecticides against wireworms (*Elateridae*) in sugar beet crops, expressed through relative stand density in 2004

als/m^2), crop density was from 3.1—8.6% higher than in the control in the cases of carbofuran, its mixture with bifenthrin, the two higher doses of thiamethoxam and the higher dose of its mixture with tefluthrin to 11.3—19.6% (the highest percentage was obtained with clothianidin). In the location of Sombor (1.6 larvae/m^2), the stand was from 6.3% higher (in the case of carbofuran + bifenthrin) to 30.2% (in the case of imidacloprid, 50 g a.s./s.u.).

In 2003 and 2004, the occurrence of *B. punctiventris* in the examined locations was either very low or very intensive (when foliar treatments had to be performed), so that it was not possible to make valid estimates of the activity of the applied insecticides.

The effect of seed treatment on beet flea beetle. The occurrence of *C. tibialis* was intensive in 2001 and 2003 and medium in 2004. As the occurrence of the pest was limited to the location of R. Šančevi, insecticide efficiency was assessed only in that location. As the results from 2001 and the part of 2003 experiments had already been reported, this paper deals only with the results from the last two years.

On 8 May 2003, about 40 days after planting, 25 plants were sampled from each experiment unit (i.e. 100 plants per treatment), at the phenophase of 2—3 pairs of permanent leaves and assessed in laboratory for the intensity of damage by beet flea beetles and measured for plant weight. In the conditions of high population density of beet flea beetles, high air temperatures (maximum daily temperatures ranging between 28 and 32°C) and exceptionally low rainfall (8 mm in April and 9 mm in May), practically all plants were damaged but with various levels of damage intensity (according to the scale of Sekulić et al., 2002). In the control and the treatment with terbufos (Table 3), there were no slightly damaged plants (1—10 holes per plant), 12% and 15% of plants, respectively, were medium damaged (11—50 holes per plant) and 88% and 85% of plants, respectively, were intensively damaged (over 50 holes per plant). The treatment with tefluthrin provided poor control of beet flea beetles (5% slight damage, 33% medium damage and 62% intensively damaged plants). However, tefluthrin mixture with imidacloprid, and especially with thiamethoxam provided very good control of beet flea beetles (75—97% respectively slight damage, 4—15% medium damage and only 0.8—14% intensively damaged plants).

Table 3. The effect of seed treatment by insecticides on young plants weight of sugar beet and injury level from *Chaetocnema tibialis* (Rimski Šančevi, 2003)

Active substance	Amount of active substance (g, ml/unit)	Young plants weight (g)	% of plants with different injury level from *C. tibialis*			
			no injuries	low	medium	high
Imidacloprid + tefluthrin	15 + 4	71.8	0.0	75.0	11.0	14.0
Tefluthrin	8	43.0	0.0	5.0	33.0	62.0
Thiamethoxam	60	65.8	0.0	96.8	3.2	0.0
Thiamethoxam + tefluthrin	15 + 6	75.8	0.0	84.0	15.2	0.8
Thiamethoxam + tefluthrin	60 + 4	77.6	0.0	96.0	4.0	0.0
Terbufos	25.0 kg/ha	30.9	0.0	0.0	15.0	85.0
Control	—	23.0	0.0	0.0	12.0	88.0

The weight of 25 young plants was the largest (71.8—77.6 g) with plants that emerged from seeds treated with mixtures of the insecticides imidacloprid and thiamethoxam with the pyrethroid tefluthrin. The weight was slightly smaller (65.8 g) with the treatment of thiamethoxam alone. Significantly lower weights were obtained with tefluthrin and terbufos (43.0 and 30.9 g, respectively) and in the control (only 23.0 g).

During the second assessment in 2004, about 50 days after planting (20 May), 100-plant samples were examined in the laboratory at the phenophase of 2—3 pairs of permanent leaves and the same parameters were assessed as in the previous year. The percentage of damaged plants from *C. tibialis* was very high in all treatments and control (62.5—98.4%), but damage extent was very different (Table 4). Almost all insecticides provided high percentages of slightly damaged plants (31.7—74.2%), low portions of medium damaged plants (1.71—39.2%) and the lowest portions of intensively damaged plants (0—21.7%).

Table 4. The effect of seed treatment by insecticides on young plants weight of sugar beet and injury level from *Chaetocnema tibialis* (Rimski Šančevi, 2004)

Active substance	Amount of active substance (g, ml/unit)	Young plants weight (g)	% of plants with different injury level from *C. tibialis*			
			no injuries	low	medium	high
Carbofuran	4.0 l/100 kg seed	32.2	1.6	74.2	21.7	2.5
Carbofuran + bifenthrin	2.0 + 0.2/100 kg seed	30.2	11.7	31.7	35.0	21.6
Imidacloprid	25	36.8	2.5	56.6	39.2	1.7
Imidacloprid	50	45.4	12.5	73.3	14.2	0.0
Imidacloprid	90	39.7	37.5	60.8	1.7	0.0
Tefluthrin	5.0 kg/ha	35.9	8.3	55.0	35.9	0.8
Thiamethoxam	15	34.3	7.5	73.3	16.7	2.5
Thiamethoxam	20	38.1	20.8	53.3	25.9	0.0
Thiamethoxam	30	37.0	26.7	43.3	8.3	21.7
Thiamethoxam + tefluthrin	15 + 6	41.8	26.6	55.0	9.2	9.2
Thiamethoxam + tefluthrin	15 + 8	38.8	26.7	70.0	3.3	0.0
Clothianidin	68	35.7	28.3	61.7	9.2	0.8
Terbufos	25.0 kg/ha	23.7	2.5	74.2	23.3	0.0
Control	—	23.0	2.5	33.3	50.9	13.3

The weight of 25 juvenile plants was the highest in the plants that emerged from the seeds treated with imidacloprid (37—45.4 g) and mixtures of thiamethoxam and tefluthrin (38.8—41.8 g). Slightly lower values (34.3—38.1 g) were achieved with thiamethoxam applied alone, clothianidin and granulated tefluthrin. Significantly lower values were achieved with terbufos (23.7 g) and in the control variant (23.0 g).

DISCUSSION

When referring to seed treatment with insecticides, one has in mind primarily plant protection against soil-dwelling pests, but also a complete or partial protection of scant foliage of the young plants from different weevils, flea beetles and other pests which attack sugar beets at the beginning of growing season. Sugar beet seed treatment is performed more frequently than it is the case with other crops. In 18 countries of West Europe, insecticide-treated sugar beet seeds are used at 80% of the sugar beet acreage (Dewar and Asher, 1994). The effects of seed treatment with insecticides are amply discussed in international and domestic literature. Altmann (1991), for example, points out the duration of action of imidacloprid (2—3 months) and its efficiency in the control of beet flea beetle, as well as of the species *Atomaria linearis*, *Agriotes lineatus* and *Pegomyia hyoscyami*. Wauters and Dewar (1994) report similar data on the action of imidacloprid, but they also mention that carbofuran provides good protection of young sugar beet crops against beet flea beetle, beet leaf miner and *Lygus* bugs. Kimel (1997) in Hungary and Fedorenko and Demjanuk (2003) in Ukraine recommend seed treatment for control of beet weevil if its numbers in old sugar beet fields do not exceed 1—2 individuals per m^2.

Studies conducted in our country (Sekulić et al., 1998—2002; Kereši et al., 2003, 2004) showed that seed treatment with insecticides, in addition to controlling soil pests in row crops (with the pest population density up to 5 individuals per m^2) successfully controls gray corn weevil in young corn crops, leafcurl plum aphid (*Brachycaudus helichrysi* Kalt.) and corn weevil in sunflower as well as beet flea beetle in young sugar beet crops, or at least reduces the number of field treatments needed for their control.

In the experiments conducted in the period of 2001—2004, especially in 2003, almost all of the tested seed treatment insecticides and their mixtures ensured a significantly better stand of sugar beet crop than the control variant. The highest effects in the maintenance of crop stand were registered in all years in the location A. Šantić, where the population density of the elaterid larvae was the highest. In the first two years of study, in the location Kljajićevo, considerable reductions of the percentage and intensity of damage of young plants by beet weevil were achieved by the application of thiamethoxam and imidacloprid.

The effect of seed treatment on beet flea beetle was most evident in the location R. Šančevi during 2001 (Sekulić et al., 2002) and 2003. In the spring of 2003, the best protection of young plants from beet flea beetles was achieved with thiamethoxam, applied alone or in mixture with tefluthrin and a mixture of imidacloprid + tefluthrin. These treatments ensured significantly lower percentages of damaged plants and intensities of damage than the control variant, while simultaneously ensuring significantly higher plant weight. Similar results, in the same year and in the same location, were obtained with the application of thiamethoxam and a mixture of carbofuran and bifenthrin to encrusted sugar beet seeds (Kereši et al., 2004).

Taking into consideration our own long-termed experience in that field, results of numerous studies conducted around the world and the fact that in the European Union as well as in Ukraine treated sunflower and sugar beet seeds are used practically at the entire acreages of these crops, the use of seed treatment should be expanded in our country because, evidently, it is fully both economically and ecologically justified.

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СУЗБИЈАЊЕ ШТЕТОЧИНА ШЕЋЕРНЕ РЕПЕ У ПОЧЕТНОМ ДЕЛУ ВЕГЕТАЦИЈЕ ТРЕТИРАЊЕМ СЕМЕНА ИНСЕКТИЦИДИМА

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Резиме

Током 2001—2004. године на подручју Бачке утврђивана је ефикасност инсектицида за третирање семена шећерне репе у циљу сузбијања штеточина у земљишту (ларве фам. *Elateridae*) и смањења штета од репине пипе (*Bothynoderes punctiventris* G e r m.) и репиног бувача (*Chaetocnema tibialis* I l l.). Тестирано је више инсектицида, претежно системичних (карбофуран, тиаметоксам, фипронил, имидаклоприд и клотианидин) и њихових комбинација са пиретроидима у различитим дозама. Оцена ефикасности изражена је преко оствареног биљног склопа, процента биљака оштећених од пипе и бувача, интензитета оштећености од бувача и масе младих биљака.

Ефекат испитиваних инсектицида је варирао, зависно од густине популације штеточина и временских услова у периоду истраживања. Највеће повећање склопа у односу на контролу регистровано је у 2003. години (25—32% на Р. Шанчевима, 21—77% у Сомбору и 63—116% у А. Шантићу), али је и у осталим годинама било врло добро (нарочито у А. Шантићу). Најбоља заштита младих биљака од репине пипе остварена је 2001. и 2002. године у Кљајићеву.

Ефекат инсектицида на репиног бувача најочигледнији је био у 2001. и 2003. години, у локалитету Р. Шанчеви. Док је у контроли 85—100% биљака било оштећено претежно јако, у третманима са имидаклопридом, тиаметоксамом и њиховим мешавинама са пиретроидима проценат оштећених биљака је био много мањи, интензитет оштећености је углавном био слаб, а маса биљака већа.

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EFFECTIVENESS OF DIFFERENT TRAP DESIGN IN MASS TRAPPING OF *BOTHYNODERES PUNCTIVENTRIS* GERMAR.*

ABSTRACT: The discovery of an aggregation attractant for *Bothynoderes punctiventris* Germ. raised several questions for possible improvements of IPM of *Bothynoderes punctiventris* in sugar beet. First results on exploration of possibilities for its use for monitoring purposes as well as for mass trapping of adults of the pest are described in this paper. Trap design effectiveness was evaluated in the overwintering fields of sugar beet weevil for two years in localities in Serbia and Hungary. Among trap designs tested, it was proved that baited CSALOMON® TAL trap design was optimal.

KEY WORDS: aggregation attractant, *Bothynoderes punctiventris*, sugar beet, traps

INTRODUCTION

Sugar beet weevil is an important sugar beet pest (Čamprag, 1963, 1973). In some years it can cause severe damages by cutting young sugar beet plants. Adult insects are relatively large and they are good flyers during the warm weather. Its control is difficult and mainly based on chemical insecticides (Sekulić et al., 1997). Critical period of insect activity is during warm sunny weather, early in the spring — during April, when adults are capable of flying and infesting fields with newly emerged sugar beet plants. Due to very frequent and long-term intensive use of chemicals, sugar beet weevils lowered

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sensitivity to applied insecticides is already registered in some localities in Serbia (I n đ i ć et al., 1995).

New administrative regulations within EU market as well as environmental concerns and demands for more ecological pest management and less polluted environment has as the consequence the reduction of market — available chemical insecticides used, so far, as standard control means against sugar beet weevil (Anonymous, 2002).

All these facts created the basis and need for exploring new methods which can fulfill requirements for environmentally safe and sustainable sugar beet production and protection.

The discovery of an aggregation attractant for *B. punctiventris* facilitated resea h on its properties and possible means of application (T ó t h et al., 2002 a, b, c). Our goal in this paper was to investigate the use of formulated aggregation attractant in different trap designs in order to find out an optimal trap which can be recommended and used for monitoring the population density changes and for mass trapping of *B. punctiventris* adults.

MATERIAL AND METHODS

Trap designs, field tested for their effectiveness are represented in Figure 1.

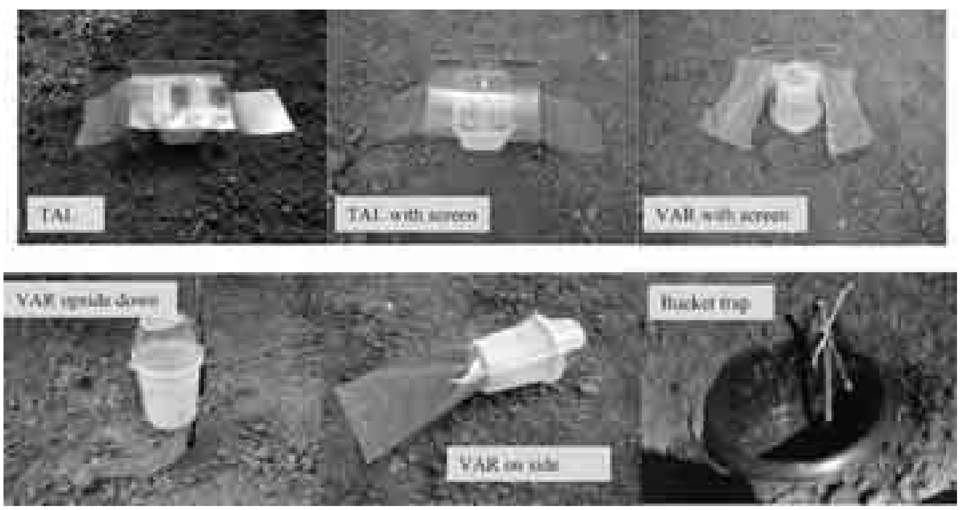

Figure 1. Trap designs used for trap efficiency testing in Serbia and Hungary 1999 and 2000

In Serbia, trials were set up during 1999 and 2000, early in the spring. In the vicinity of Zemun Polje, former sugar beet field as over wintering site for *B. punctiventris* G e r m. was chosen. In both years, sets of five different traps were tested in five replicates. Replicates were located 100 m from each other. Traps in each replicate were placed in a circle and 15 m apart from one another. In 1999, traps were placed in the field on 17th March and the number of beetles caught was registered up to 5th April. In 2000, traps were operated between 28th March up to 5th May.

Field trials of trap design efficiency in Hungary were set up in 1999, in locality Pusztaszabolcs and traps were in the field from April 23rd to May 20th and in 2000, in localities Adony, April 1st—May 5th and Debrecen, April 12th—May 9th. Tested traps were placed in the field according to the same protocol and design as described above.

In order to compare efficiency of the optimal trap design with other means of population estimation methods, we organized field trials in Serbia, Žarkovci, April 9th—May 25th, 1999 and in locality Pančevo, April 13th—Jun 20th. In these trials, we used 10 standard baited TAL traps and 10 unbaited TAL traps and visual population density estimation using wooden frame of $1m^2$. Traps were placed on the 1 ha of newly planted sugar beet field in zig-zag pattern, while visual checking was done during each inspection date.

Bait longevity test was done in Serbia, locality Žarkovci May 28th—July 8th. For this purpose, we used baits in traps already exposed in the sugar beet field for 2 months as well as fresh ones. There were 14 baits, two months old and 11 fresh baits placed in the field in zig-zag order.

RESULTS

During preliminary tests, it was estimated that adults are avoiding sticky surface so, at the beginning of designing traps for testing, sticky traps were omitted. Besides that, adult size and behavior predetermined the use of traps without glue. Since sugar beet weevil adults are crawling on the soil, it was clear that there has to be some kind of support for the insects before they fall down to the pot of the trap. Therefore, variations of TAL and VAR (funnel) traps with and without supporting screen for crawling insects were tested.

Results obtained in field test in Serbia during 1999 showed that among six different designs, the most efficient was the standard TAL trap. Its efficiency was not statistically different from TAL trap covered with screen, bucket trap and VAR placed on side (Figure 2). Based on these results, we omitted ineffective designs from further testing and during 2000, we tested TAL trap, bucket trap and VAR with screen trap with and without bait. Results showed that the highest number of sugar beet weevil adults was caught in bucket traps and TAL traps. The difference between these two designs and others in the trial was statistically significant. The bucket trap effectiveness improvement was due to proper placement of the traps edge on the level of the soil surface. It is noticeable that with TAL design, there were no similar problems since these traps contain support for crawling insects to enable entering the trap. These trials also showed significant differences between baited and unbated traps.

Results of the tests done in Hungary during 1999 showed that TAL traps with and without supporting screen are catching significantly more adults of *B. punctiventris* than other designs. Also, unbaited traps are catching significantly less number of beetles than baited (Figure 3).

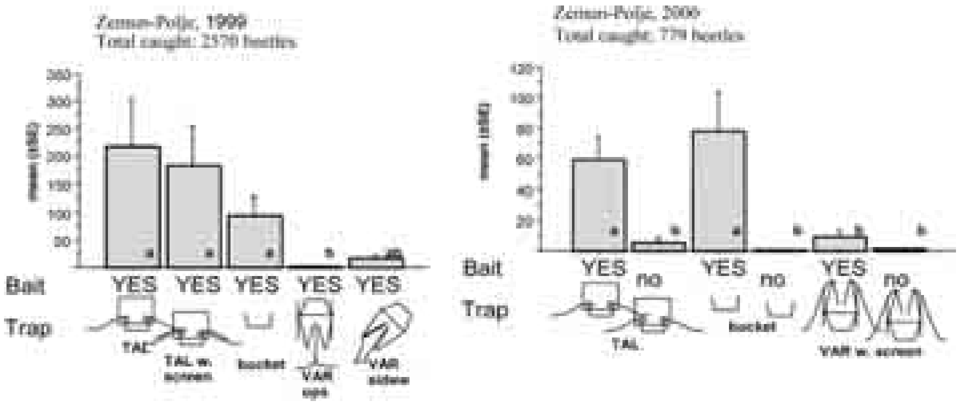

Figure 2. Efficiency of different trap designs in trials in Serbia 1999 and 2000

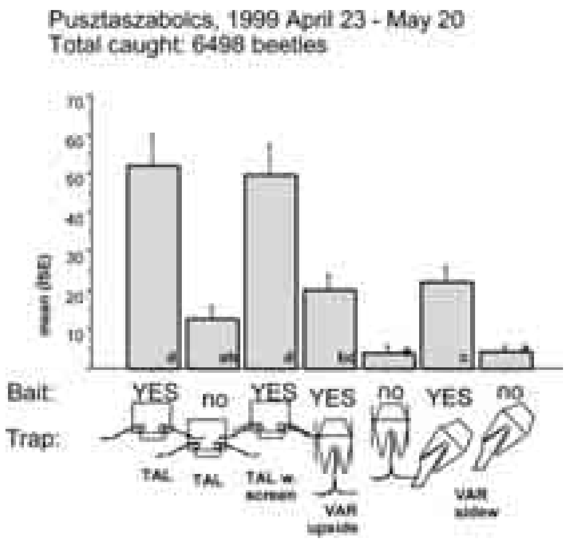

Figure 3. Efficiency of different trap designs in trial in Hungary 1999

Further tests, during 2000 in Adony and Debrecen showed that the TAL trap design was the most efficient in catching sugar beet beetles (Figure 4).

Based on the overall results, we concluded that among tested trap designs, baited TAL traps were optimal for beetle catching. Its design takes into consideration the behavior of the pest insect which makes that trap more sensitive. During the tests, it became clear that traps effectiveness is not decreasing and that trap has high catching capacity of up to 1.000 beetles.

In tests set up in Serbia during 1999 and 2000, we compared standard methods of sugar beet weevil adult population monitoring with catches on TAL traps. Results from these trials showed the advantages of using TAL trap baited with aggregation attractant (Figure 5). Baited traps are catching more beetles that unbaited and results on insect density and activity are more consistent and realistic. Since insect activity is under high influence of temperature, which is highly variable in April and May, results on insect activity and density are much more precise than visual checking.

Bait longevity test was done in Serbia in 2000. It clearly showed that baits used in traps in the sugar beet field for two months were as attractive as fresh ones (Figure 6). This is very important since there is no need to replace baits in the traps already mounted in the sugar beet field. Baited traps retain their activity throughout the full *B. punctiventris* flight season. Aggregation attractant is also efficient during copulation and oviposition period.

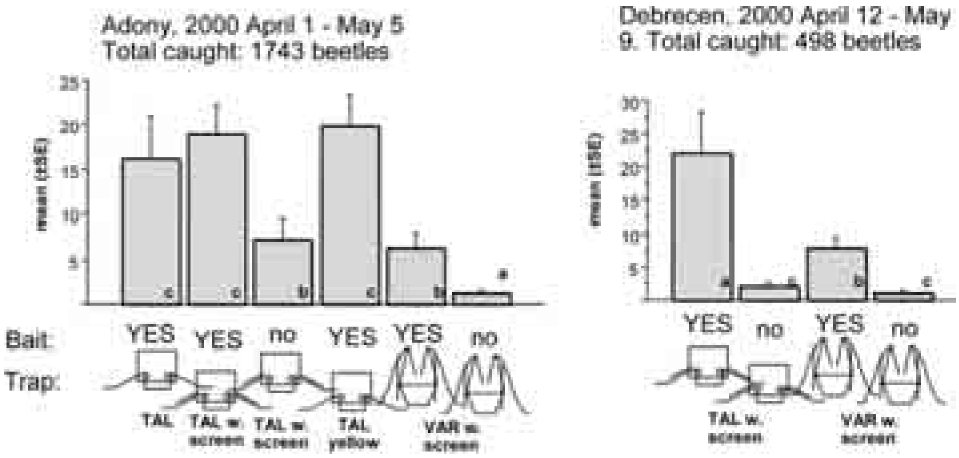

Figure 4. Efficiency of different trap designs in trials in Hungary 2000

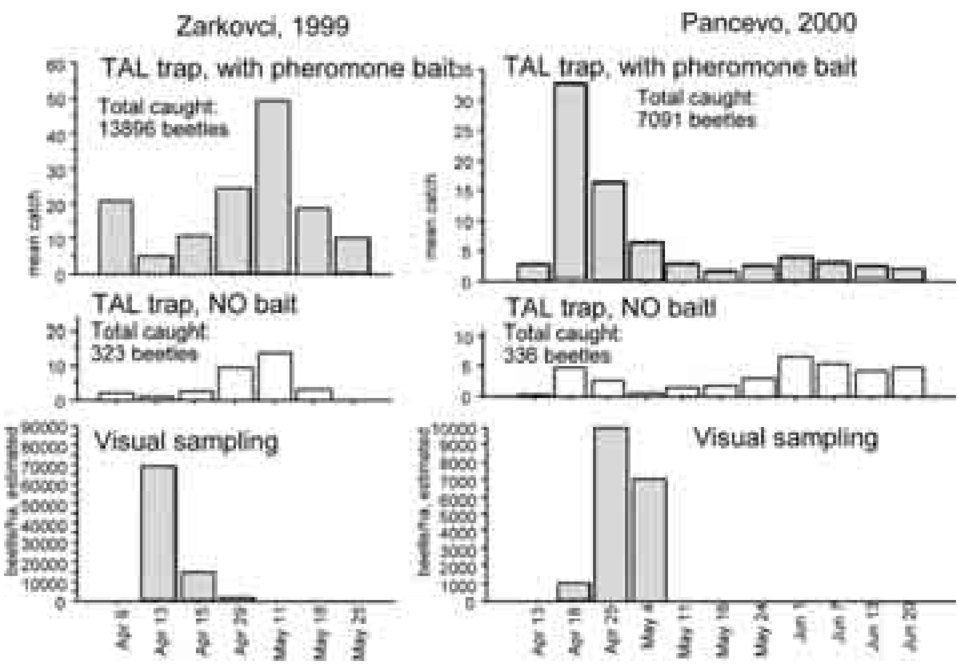

Figure 5. Number of adults in baited and unbaited TAL traps and by visual checking

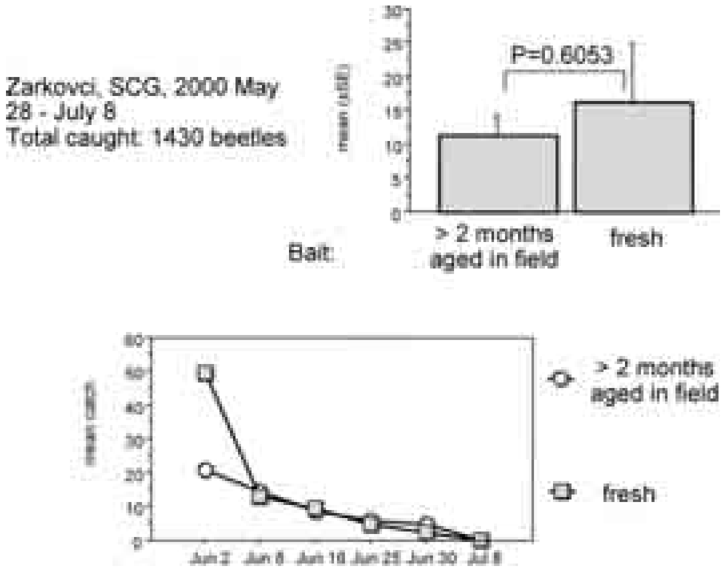

Figure 6. Baith longevity test: comparison of efficiency of 2 months old baits and fresh baits

DISCUSSION

In our tests it was proved that the specially designed "TAL" trap is much more sensitive in detecting the presence of the pest as well as it monitors population levels more accurately than other available methods and traps used in entomology for insect trapping and monitoring. Baited traps are very sensitive and can be reliable and useful even in the state of sugar beet weevil low population levels. It can be expected that the usage of traps for monitoring purposes is going to replace standard methods of population estimation like checking the number of overwintering adults in the randomly selected soil samples of 50 x 50 x 50 cm size. This widely recomended and standard method is time consuming, needs several workers and depends very much on the number of samples. Usually, this method was applied in large, state farms while for smaller producers with several sugar beet fields it was not appropriate and was not used frequently. Therefore, these producers were not quite aware of sugar beet weevil population density in overwintering sites (former sugar beet fields) as well as of infestation levels in newly planted sugar beet fields.

Simplicity for usage and efficiency in monitoring beetle population density is the key advantage of TAL trapping method. Effectiveness of other applied methods in sugar beet control can be enhanced. Primarily, it is a thorough, easy and precise estimation of owervintering population density, precise following of weevils settlement into newly planted sugar beet fields and especially, thorough possibility for timely insecticide application. Besides monitoring purposes, the number of sugar beet weevils caught is very high and therefore, the effect of mass trapping is very important as well. According to the preliminary results, proportion of trapped insects is significant and can be as high as 100% (Tomašev et al., 2003, 2005).

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ЕФИКАСНОСТ РАЗЛИЧИТИХ ОБЛИКА КЛОПКИ У МАСОВНОМ ИЗЛОВЉАВАЊУ *BOTHYNODERES PUNCTIVENTRIS* GERMAR.

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Резиме

Репина пипа (*Bothynoderes punctiventris* G e r m a r.) је важна штеточина шећерне репе. Њено сузбијање у великој мери зависи од инсектицида хемијског порекла. Интензивна употреба оваквих инсектицида довела је до појаве резистенције у неким популацијама. Новија законска решења и захтеви за бољом животном средином довели су до ограничавања броја тржишно расположивих инсектицида. Стога се намеће потреба за изналажењем стратегије и нових начина одрживог сузбијања репине пипе. Овакве методе су неопходне произвођачима шећерне репе. Откриће агрегационог атрактанта репине пипе омогућава развој и примену нових метода праћења популационе густине као и за сузбијање масовним изловљавањем.

Више типова клопки је у пољским условима поређено у циљу изналажења најефикаснијег дизајна у изловљавању гмижућих репиних пипа. Барбери посуде, које се дуго користе за изловљавања у ентомологији, модификоване су у циљу подизања њихове ефикасности и једноставности употребе. Овакав облик клопке је означен као TAL и знатно је осетљивији од класичне Барбери посуде. Током ловне сезоне може да улови до 1000 пипа док задржава активност током сезоне. Ефикасност класичних Барбери посуда повећали смо употребом посуда већих димензија са циљем да се користе у масовном изловљавању.

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FLIGHT DYNAMICS OF SOME *LEPIDOPTERA* SPECIES OF SUGAR BEET AND POSSIBILITIES THEIR CONTROL (TRANSYLVANIA—ROMANIA)*

ABSTRACT: In this paper, the authors present the obtained results regarding the flight dynamics of some *Lepidoptera* species in sugar beet crops in Transylvania (the central part of Romania). In order to limit the appearance of mentioned pests to the economic threshold, *Trichogramma* spp. were obtained in laboratory conditions at ARDS Turda and SBRDS Brasov. The experiments were conducted in production areas on 0,5 ha minimum for each variant. The variants included four *Trichogramma* species: *T. dendrolimi, T. evanescens, T. maidis, T. buesi* that were manually released three times: the first release, 10.000 individuals/ha, the second, 120.000 individuals/ha and the third, 150.000 individuals/ha. The first release was performed at the beginning of the *Lepidoptera* flight, the second at the maximum flight and the third 5 days after the second.

The efficiency of *T. maidis* was between 75—90%, of *T. evanescens*, it was between 73—88%, of *T. dendrolimi*, it was between 85—92% and of *T. buesi* 79—82%. Among the *Trichogramma* species utilized, *T. dendrolimi* and *T. evanescens* were very efficient in the reduction of mentioned pests. Root production was significantly higher compared to the untreated variant, 4,0—4,7 t/ha more were recorded after the application of biological treatments with *T. evanescens* and *T. dendrolimi*.

KEY WORDS: Biological treatments, flight dynamic, *Lepidoptera* species, pheromonal traps, *Trichogramma* spp., roots production

INTRODUCTION

In Romania, sugar beet areas were significantly reduced in the last years. Nowadays, there are approximately 20.000 ha of sugar beet, about 6.000 ha in Transylvania. It is very important to study the fauna composition inhabiting that biocenosis, as well as the activity of present species. In this way, it is necessary to know the ecology, biology of pests, behaviour and the population

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size of these. On the basis of the obtained results, the monitoring of species evolution was done.

At the Chemistry Institute of Cluj Napoca, a large spectrum of sexual pheromones was synthesized which were then tested on a series of lepidopterous pests harmful for sugar beet crops. Further on, some abundance aspects of the most harmful lepidopterous pests in Transylvania were presented (Turda and Brașov area) and some biological control aspects, also.

MATERIAL AND METHOD

Researches regarding the flight dynamics of lepidopterous pests were performed at ARDS Turda and SBRDS Brașov, between 1994—2003. The monitored species were: *Autographa gamma, Agrotis segetum, Agrotis exclamationis, Agrotis ypsilon, Amathes c-nigrum, Mamestra suasa, Mamestra trifolii, Mamestra brassicae*. For setting the population dynamics of these pests, Romanian sexual pheromones were used. The experiment included three repetitions, the traps being placed at 50 m distance between them and the captured insects were recorded. The abundance of target species and other species of captured lepidopterous pests were monitored for pointing out the attractiveness of sexual pheromones for target species. The results of these observations were materialized through flight curves, which show the species evolution depending on climatic conditions, which can serve as a warning that chemical or biological treatments should be applied. Some experiments with biological treatments with *Trichogramma* species, *T. dendrolimi, T. evanescens, and T. maidis T. bues* were conducted in field conditions. The area of a variant was 0,5 ha. There were three releases of *Trichogramma* spp.: 100.000 individuals/ha at the first release, 120.000 individuals/ha at the second and 150.000 individuals/ha at the third release. The first release was done at the beginning of the lepidopterous pests flight, the second one at the maximum flight and the third one 5 days after the second one. The observations regarding the treatments efficiency were done on the frequency of the attacked plants and on the obtained root yield.

RESULTS AND DISCUSSIONS

Between 1994—2004 (May—September), the medium value of temperature was between 15—22°C, in May, a medium temperature of 17°C was recorded, in July and August 20—22°C and in September 15—16°C. The amount of rainfall was between 27—46 mm, the highest value recorded in June, in May and July being 27 mm and up to 21,5 mm in August and September. These climatic conditions proved that the flight of lepidopterous pests is harmful for sugar beet crops. Since being thermophile, the maximum flight was at 18—21°C.

The specific sexual pheromones for lepidopterous pests presented the attractiveness between 85—96% in Turda and between 87—94% in Brașov. Other lepidopterous species were in pheromone traps accidentally and not because of their attraction to sexual pheromones which are specific and selective for target species in a considerable proportion (Table 1).

Table 1. Specific attractiveness (%) of sexual pheromone in the both counties (May—September, 1994—2003)

The species	Specific attractiveness of sexual pheromones (%)	
	ARDS Turda	SBRDS Brașov
Autographa gamma	85,0	89,2
Amathes c-nigrum	93,0	91,3
Agrotis segetum	96,0	87,0
Agrotis ypsilon	95,0	93,8
Agrotis exclamationis	94,0	94,0
Mamestra trifolii	95,4	90,4
Mamestra suasa	94,3	93,4
Mamestra brassicae	95,1	94,0

Owing to good attractiveness and selectivity of sexual pheromones for monitoring the species, high abundance of them was present during the whole period of the studying years in both areas (over 18.000 and 30.000 adults in Turda and Brașov respectively) (Figure 1).

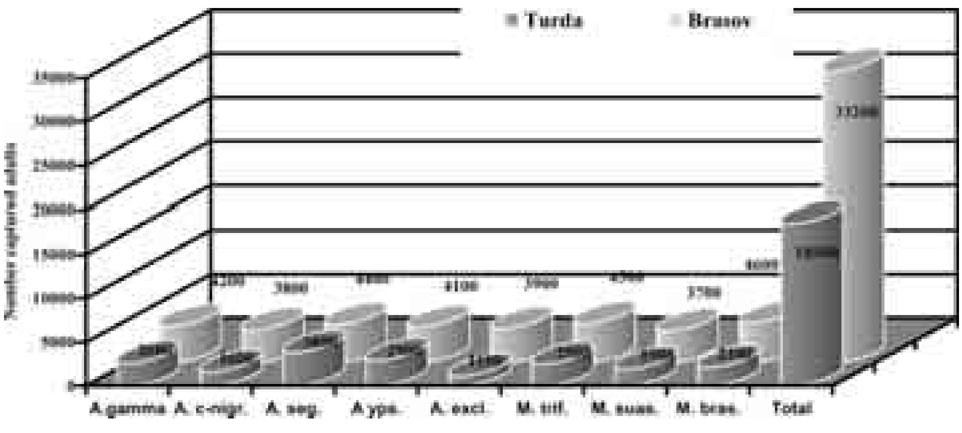

Figure 1. Abundance of *Lepidoptera* damaging sugar beet captured in sexual pheromone traps (May—September, 1994—2003)

The evolution of mentioned species depending on climatic conditions is presented in the flight curves. The adults flight of *Autographa gamma* and *Amathes c-nigrum* began in May, growing higher in June when the medium temperature was 18—19°C, the period when besides the native exemplars, those from Southern Europe migrating to North also appear. The first maximum flight was recorded in the second (*A. gamma*) and third (*A. c-nigrum*) decade of June, afterwards the flight continued but at lower values, followed by intensification in August when the second maximum flight was recorded, *A. c-ni-*

grum in the first and *A. gamma* in the second decade. The species were also present in September but in reduced number (Figure 2).

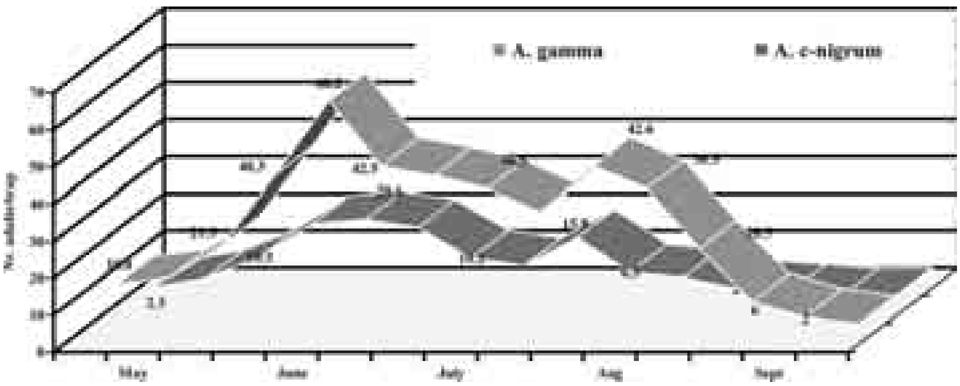

Figure 2. Flight curves of *Autographa gamma* and *Amathes c-nigrum* in sugar beet crops (Turda, 1994—2003)

The number of male species of *Agrotis segetum* and *Agrotis exclamationis* recorded in pheromone traps was higher than that of *Agrotis ypsilon* species. For the first two mentioned species, the first maximum flight was recorded at the end of June and the beginning of July when the medium temperature was about 19—20°C. The flight also continued with another maximum at beginning of the second decade of August at 21°C and with the amount of rainfall being 10—14 mm. For *A. ypsilon*, the first maximum was recorded in the second decade of July and the second one in the third decade of August (Figure 3).

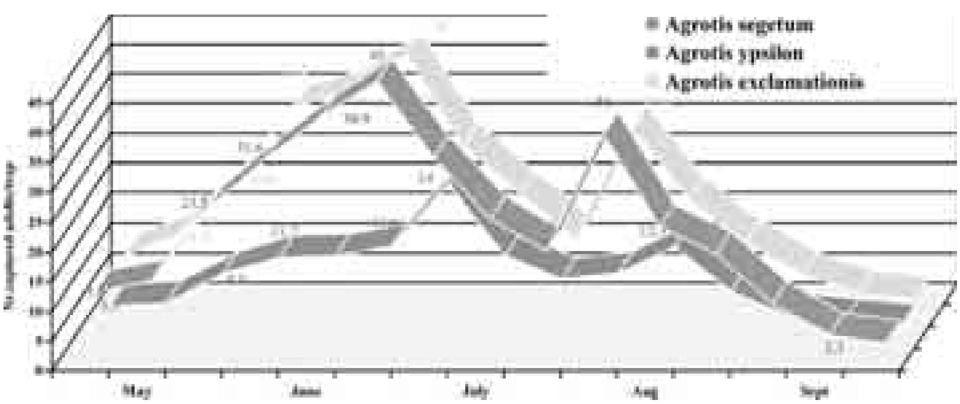

Figure 3. Flight curves of *Agrotis segetum, A. ypsilon, A. exclamationis* in sugar beet crops (Turda, 1994—2003)

The *Mamestra* genus was represented by *M. trifolii, M. suasa* and *M. brassicae*. In the pheromone traps, there was a higher number of *M. trifolii* and *M. brassicae* species. The first flight maximum was recorded in the first decade of July for all these species. Afterwards, the flight continued with low oscillations and another maximum recorded in the second decade of August (Figure 4).

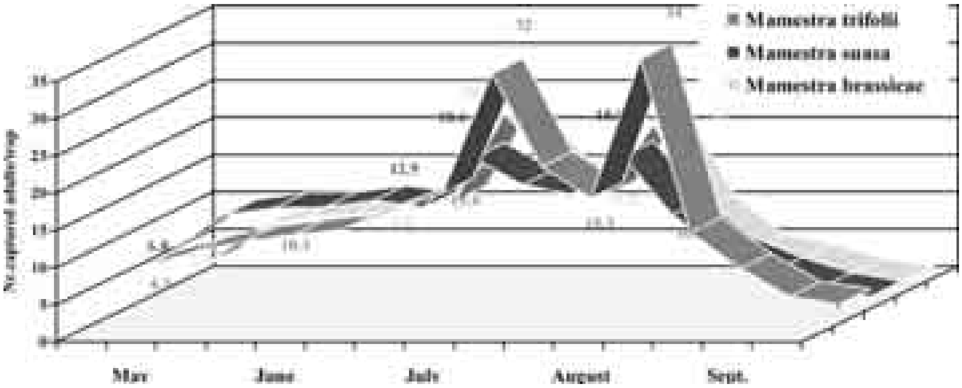

Figure 4. Flight curves of *Mamestra trifolii, M. suasa, M. brassicae* in sugar beet crops (Turda, 1994—2003)

In order to limit the number of these species, biological treatments with some *Trichogramma* species, *T. maidis, T. dendrolimi, T. evanescens, T. buesi*, were applied. The efficiency of these treatments was between 88—95% in Turda, the highest efficiency presented by treatments using *T. dendrolimi* and *T. evanescens* (Figure 5). In Brașov, the efficiency was between 92,6—94,6%, where besides two mentioned species, treatments with *T. buesi* also presented high efficiency (Figure 6). Statistical calculations resulted in that root yield obtained after the treatments with *Trichogramma* species was significantly higher, especially after treatments with *T. dendrolimi* and *T. evanescens*. The yield increase was about 4,4—4,7 to/ha compared to untreated variant (Figure 7).

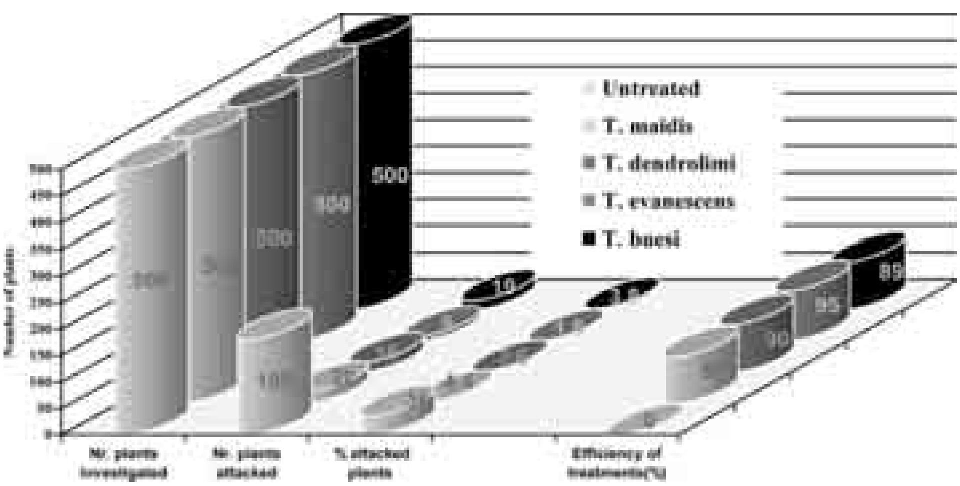

Figure 5. Efficiency of treatments with *Trichogramma* spp. in sugar beet crops (Turda, 1994—2003)

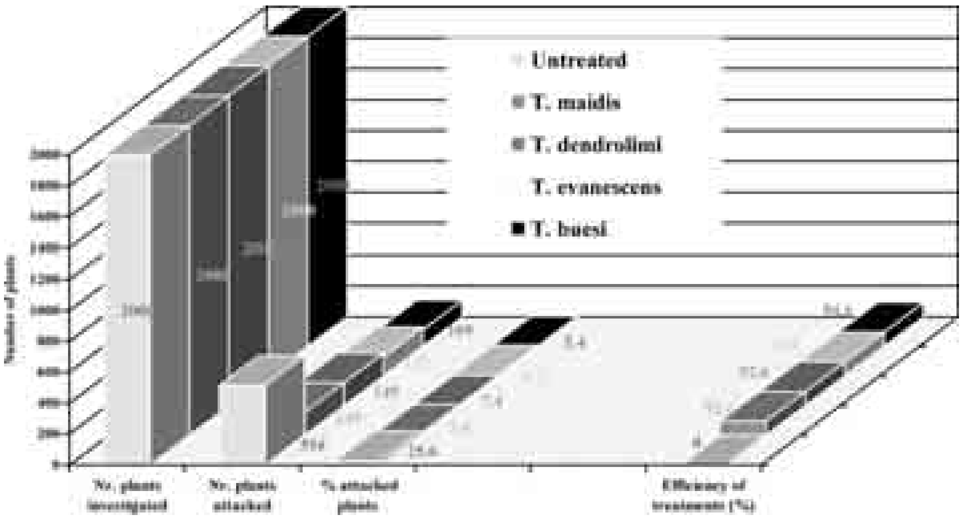

Figure 6. Efficiency of treatments with *Trichogramma* spp. in sugar beet crop (Brașov, 1994—2003)

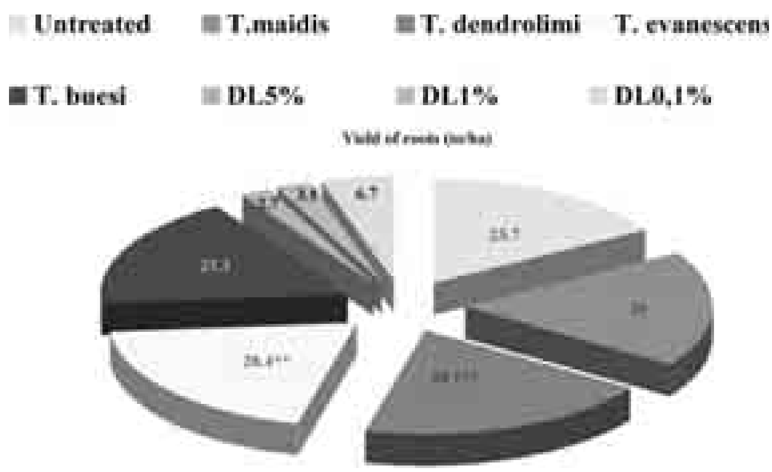

Figure 7. Root production (to/ha) obtained after treatments with *Trichogramma* spp. in sugar beet crops (Brașov, 1994—2003)

CONCLUSIONS

1. During 10 years of studying sugar beet at ARDS Turda and SBRDS Brașov, over 50.000 individuals of the mentioned species were captured in sexual pheromone traps.

2. High number of individuals was captured because of great capacity of sexual pheromones attractiveness for each species, which oscillated between 85—96% in both areas in Transylvania.

3. The placing of sexual pheromones in natural habitat of species and recording the captured number in correlation with climatic factors enabled the mapping out of flight curves which through their forms, number and capture period pointed out the number of generations of species developed in a certain ecological area.

4. The efficiency of biological treatments with four *Trichogramma* species which was between 73—92% depends on the species utilized. *T. dendrolimi* and *T. evanescens* significantly reduced the attack frequency, compared to untreated variant. Also, a significantly higher root yield with 4—4,7 to/ha more was recorded in treated variants.

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ДИНАМИКА ЛЕТА НЕКИХ ВРСТА *LEPIDOPTERA* У ШЕЋЕРНОЈ РЕПИ И МОГУЋНОСТИ ЊИХОВОГ СУЗБИЈАЊА (ТРАНСИЛВАНИЈА — РУМУНИЈА)

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Резиме

У условима Трансилваније (Пољопривредна истраживачко-развојна станица Турда и Пољопривредна истраживачко-развојна станица за шећерну репу Брашов), у периоду мај—септембар 1994—2003, у усеву шећерне репе је у феромонским клопкама прикупљено преко 40.000 јединки *Lepidoptera*: *Autographa gamma, Agrotis segetum, Agrotis exclamationis, Agrotis ypsilon, Amathes c-nigrum, Mamestra suasa, Mamestra trifolii, Mamestra brassicae*. До великог броја одраслих јединки поменутих врста дошло је због изразито доброг капацитета привлачења сексуалних феромона, за сваку врсту између 60 и 95%.

У овом раду аутори износе резултате добијене у односу на динамику лета неких врста *Lepidoptera* у усеву шећерне репе из Трансилваније (централни део Румуније) За ограничавање поменутих штеточина у економском прагу употребљене су *Trichogramma* spp. добијене у лабораторијским условима у ПИРС Турда и ПИРССР Брашов. Експерименти су изведени у производним условима области на минимално 0,5 ha за сваку варијанту. Варијанте су сачињавале четири врсте *Trichogramma*: *T. dendrolimi, T. evanescens, T. maidis, T. buesi*. Уношење ових врста *Trichogramma* у поље је урађено ручно, са три уношења: прво уношење — 10.000 јединки/ha, друго — 120.000 јединки/ha и треће — 150.000 јединки/ha. Прво избацивање изведено је на почетку лета *Lepidoptera*, друго у време максималног лета, а треће 5 дана након другог.

Посматрање ефикасности третмана изведено је на учесталости нападнутих биљака и постигнутој производњи корена. Ефикасност *T. maidis* је била између 75 и 90%, *T. evanescens* између 73 и 88%, *T. dendrolimi* између 85 и 92%, а *T. buesi* 79 и 82%. Примећено је да су, од примењених *Trichogramma* врста, *T. dendrolimi* и *T. evanescens*, *T. evanescens* и *T. dendrolimi*, уз забележено повећање приноса 4,0—4,7 t/ha.

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DISTRIBUTION, HOST PLANTS AND NATURAL ENEMIES OF SUGAR BEET ROOT APHID (*PEMPHIGUS FUSCICORNIS*) IN SLOVAKIA*

ABSTRACT: During 2003—2004, field surveys were realized to observe the distribution of sugar beet aphid, *Pemphigus fuscicornis* (Koch) (*Sternorrhyncha: Pemphigidae*) in southwestern Slovakia. The research was carried out at 60 different localities with altitudes 112—220 m a. s. l. Sugar beet root aphid was recorded at 30 localities. The aphid was recorded in Slovakia for the first time, but its occurrence was predicted and symptoms and harmfulness overlooked by now. The presence of *P. fuscicornis* was investigated on roots of various plants from *Chenopodiaceae*. The most important host plants were various species of lambsquarters (above all *Chenopodium album*). Furthermore sugar beet (*Beta vulgaris* provar. *altissima*), red beet (*B. vulgaris* provar. *conditiva*) and oraches (*Atriplex* spp.) act as host plants. Infestation of sugar beet by *P. fuscicornis* never exceeded 5% at single locality in Slovakia. Dry and warm weather create presumptions for strong harmfulness. In Slovakia, *Chenopodium album* is a very important indicator of sugar beet aphid presence allowing evaluation of control requirements. During the study, the larvae of *Thaumatomyia glabra* (*Diptera: Chloropidae*) were detected as important natural enemies of sugar beet aphid. The species occurred at each location evaluated.

KEYWORDS: *Pemphigus fuscicornis*, insecst, aphids, *Chenopodium*, *Beta vulgaris*, Sugar beet, *Thaumatomyia glabra*, natural enemies

INTRODUCTION

Sugar beet aphid, *Pemphigus fuscicornis* (Koch, 1857) (*Sternorrhyncha*: *Pemphigidae*) is important pest of sugar beet in Eastern Europe (Čamprag, 2003). The occurrence is known from Poland (Heie, 1980), Hungary, Bulgaria, Romania, Serbia, Croatia (Čamprag, 2003), Greece (Ioanidis, 1996), Ukraine and Russia (Pisnya and Fedorenko, 1988). Little is known about distribution in Western Europe (Heie, 1980). Accounts are available

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only for Germany (B o s c h and D u d a, 1994), Denmark, Sweden (H e i e, 1980) and Finland (A l b r e c h t et. al., 1996). Eastward and southward from Europe, there are records from Asian countries like Georgia, Armenia, Kazakhstan (Č a m p r a g, 2003) and Iran (S h a d m e h r i et al., 2001).

The species is similar to *P. bursarius*, but grayish-green, not whitish--yellow (H e i e, 1980). The rear portion of the body produces a mass of white, waxy material. The aphids are most readily seen in the white mold-like material that is found on the infested roots and in the surrounding soil. The aphid is associated with fibrous roots rather than the main root.

Over 70 *Pemphigus* species have been described until know, of which, 46 are known to form galls on leaves or twigs of *Populus*. The life cycles of 17 of these gall-formers are known; four are monoecious on *Populus*, the alate sexuparae being produced in the galls and in the other 13 species the alate progeny of the fundatrix migrate to various herbaceous secondary hosts (B l a c k m a n and E a s t o p, 1994).

Although H e i e (1980) mentioned that the primary host is unknown, B o s c h and D u d a (1994) noted that winged adults migrate from roots of secondary hosts (*Chenopodiaceae*) to the cottonwood trees (*Populus* sp.), primary hosts, where they lay their eggs. On the other hand, anholocyclic populations often persist all year on secondary hosts (Č a m p r a g, 2003). Similar species, *Pemphigus betae* Doane occur throughout the major sugar beet growing areas of North America (H u t c h i n s o n and C a m p b e l l, 1994). *P. betae* is assumed to use cottonwood or poplar trees (*Populus* spp.) as primary hosts (H a r p e r, 1963, W h i t h a m, 1978). Although sugar beet is usually the secondary host concerning economic importance, the roots of red beets, lambsquarter (*Chenopodium album*), spinach and alfalfa may also be colonized by *P. betae* (H a r p e r, 1963). Large populations of "sugar beet root aphid", *Pemphigus populivenae* F i t c h were observed to develop on quinoa (*Chenopodium quinoa*) roots in Colorado (C r a n s h a w et al., 1990).

The aim of this work was to detect the occurrence on host plants and natural enemies of *Pemphigus fuscicornis* in Slovakia.

MATERIAL AND METHODS

During the autumn seasons 2003—2004, field surveys were conducted to observe the distribution of sugar beet aphid, *Pemphigus fuscicornis* (K o c h) (*Sternorrhyncha*: *Pemphigidae*) in southwestern Slovakia. The research was carried out at 60 different, randomly chosen localities in different geographic and climatic regions. Crops, where the samples were taken were grown according to local farmers' practices. The roots of various species from *Chenopodiaceae* were used for investigation. Above all, lambsquarters (*Chenopodium* sp.), oraches (*Atriplex* sp.), sugar beet (*Beta vulgaris altissima*) and red beet (*B. vulgaris* provar. *conditiva*) were inspected. To record the presence of the sugar beet aphid, 30 lambsquater plants were inspected at each location. The number reached the maximum of 50 plants per site if sugar beet aphid were not found. In addition, 30 randomly chosen plants of cover crops (sugar beet, red beet, spinach) were also inspected. Besides sugar beet aphid, natural enemies were detected within the colonies. Recorded species were kept, reared and identified.

RESULTS

The distribution of *P. fuscicornis* in Slovakia is shown in Figure 1. The sugar beet aphid was found at 30 localities of Southwest Slovakia, confirming that it is a common insect in that region and that it is closely related to the distribution of its main host *Chenopodium album*. The species occurred at localities with altitudes 112—220 m a. s. l. Wingless and winged females of *P. fuscicornis* were found during July, September and October 2003 and 2004 at following localities, recorded host plants are shown for each location: Branč (48°13'N 18°09'E; 137 m a. s. l.), *B. vulgaris altissima*, *Chenopodium* sp.; Čeľadice (48°20'N 18°15'E; 170 m a. s. l.), *B. vulgaris altissima*, *B. vulgaris conditiv,; Chenopodium* sp.; Dolný Štál (47°56'N 17°43'E; 112 m a. s. l.), *B. vulgaris altissima*, *Chenopodium* sp.; Domadice (48°11'N 18°47'E; 168 m a. s. l.), *Chenopodium* sp.; Hontianska Vrbica (48°08'N 18°43'E; 173 m a. s. l.), *Chenopodium* sp.; Hontianske Moravce (48°11'N 18°51'E; 159 m a. s. l.) *Chenopodium* sp.; Hosťová (48°20'N 18°13'E; 198 m a. s. l.), *Chenopodium* sp.; Hurbanovo (47°52'N 18°12'E; 115 m a. s. l.), *Chenopodium* sp.; Jelka (48°09'N 17°31'E; 123 m a. s. l.), *Chenopodium* sp.; Kostolné Kračany (47°59'N 17°35'E; 8071; 119 m a. s. l.), *B. vulgaris altissima*; *Chenopodium* sp.; Ondrochov (48°08'N 18°11'E; 126 m a. s. l.), *Chenopodium* sp.; Maňa (48°09'N 18°17'E; 131 m a. s. l.), *Chenopodium* sp.; Nemčiňany (48°18'N 18°28'E; 7676; 212 m a. s. l.), *Chenopodium* sp; Nevidzany (48°17'N 18°23'E; 181 m a. s. l.), *Chenopodium* sp.; Nová Dedina (48°17'N 18°40'E; 190 m a. s. l.), *Chenopodium* sp.; Pinkové Kračany (47°58'N 17°35'E; 119 m a. s. l.), *B. vulgaris altissima*, *Chenopodium* sp.; Pribeta (47°54'N 18°19'E; 135 m a. s. l.), *Chenopodium* sp.; Santovka (48°09'N 18°46'E; 162 m a. s. l.), *Chenopodium* sp.; Sokolce (47°51'N 17°50'E; 112 m a. s. l.), *B. vulgaris altissima*, *Chenopodium* sp.; Tehla (48°11'N 18°23'E; 180 m a. s. l.), *Chenopodium* sp.; Tlmače (48°17'N 18°32'E; 220 m a. s. l.), *Chenopodium* sp.; Tomášikovo (48°05'N 17°42'E; 118 m a. s. l.), *B. vulgaris altissima*; Tôň (47°48'N 17°50'E; 112 m a. s. l.), *Chenopodium* sp.; Trávnica (48°09'N 18°20'E; 130 m a. s. l.), *Chenopodium* sp.; Veľké Chyndice (48°17'N 18°18'E; 190 m a. s. l.), *Chenopodium* sp.; Veľký Cetín (48°13'N 18°12'E; 130 m a. s. l.), *Chenopodium* sp.; Vlkanovo (47°57'N 18°14'E; 130 m a. s. l.), *Chenopodium* sp.; Vráble (48°15'N 18°19'E; 142 m a. s. l.), *Atriplex* sp., *Chenopodium* sp.; Záhorská Ves (48°22'N 16°51'E; 149 m a. s. l.), *Chenopodium* sp.; Zlaté Klasy (48°07'N 17°25'E; 124 m a. s. l.), *Chenopodium* sp.; Zohor (48°15'N 16°58'E; 146 m a. s. l.), *Chenopodium* sp.

During the study, the larvae of *Thaumatomyia glabra* (M e i g e n) (*Diptera*: *Chloropidae*) were detected as an important natural enemy of sugar beet aphid. The species occurred at each location evaluated.

Figure 1. Distribution of sugar beet root aphid (*Pemphigus fuscicornis*) in Slovakia during 2003—2004

DISCUSSION

P. fuscicornis lives on roots of *Matricaria* sp., *Tripleurospermum* sp. (A l b r e c h t et al., 1996) and wild and cultivated species from *Chenopodiaceae* family, including sugar beet (*Beta vulgaris* provar. *altissima*) (P i s n y a, 1986). We recorded lambsquarters (*Chenopodium* sp.), oraches (*Atriplex* sp.), sugar beet and red beet (*B. vulgaris* provar. *conditiva*) as host plants in Slovakia. The most important reservoir and indicators of *P. fuscicornis* presence were lambsquarters allowing evaluation of possible control requirements.

Although H e i e (1980) mentioned that the primary host is unknown, B o s c h and D u d a (1994) noted that winged adults migrate from roots of secondary hosts (*Chenopodiaceae*) to the cottonwood trees (*Populus* sp.), primary hosts, where they lay their eggs. Sugar beet aphid was not found on cottonwood trees in Slovakia. On the other hand, anholocyclic populations often persist all year on secondary hosts (Č a m p r a g, 2003), what was confirmed during our research as well.

The results show that *P. fuscicornis* is a usual insect in Southwest Slovakia with high potential to become an important sugar beet pest. The attack of sugar beet aphid reduced significantly sugar yields and sugar content as well as the other technological values of the root. In seemingly healthy plants, the presence of the root aphid reduced the yield by 7,6%, while the sugar content declined by 2,4% (S e k u l i ć et al., 2001).

During the study, the larvae of *Thaumatomyia glabra* (M e i g e n) (*Diptera*: *Chloropidae*) were detected as the only important natural enemies of sugar beet aphid. *T. glabra* is known as common predator of root aphids (C o l e, 1969). Larvae and pupae of the chloropid predator *T. glabra* were also found among the aphid colonies on the roots of quinoa (*Chenopodium quinoa*) in Colorado (C r a n s h a w et al., 1990).

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РАСПРОСТРАЊЕНОСТ, БИЉКЕ ДОМАЋИНИ И ПРИРОДНИ НЕПРИЈАТЕЉИ РЕПИНЕ КОРЕНОВЕ ВАШИ, *PEMPHIGUS FUSCICORNIS* K O C H., У СЛОВАЧКОЈ

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Резиме

Током 2003. и 2004. године праћена је распрострањеност репне коренове ваши, *Pemphigus fuscicornis* (K o c h) (*Sternorrhyncha: Pemphigidae*), у југозападној Словачкој. Посматрања су урађена на 60 локалитета на надморским висинама од 112 до 220 m. Репна коренова ваш је регистрована на 31 локалитету. То је уједно био и први налаз ова ваши у Словачкој. Претпостављамо да је ова врста ваши у овом региону присутна већ дуже време али њено присуство и симптоми на биљкама хранитељкама остали су незапажени. Присуство ове ваши смо пратили на разним врстама биљака из фамилије *Chenopodiaceae*. Најчешће нападнуте биљке биле су разне врсте пепељуга, највише обична пепељуга, *Chenopodium album*. Затим је ваш налажена на шећерној репи (*Beta vulgaris* provar. *altissima*), цвекли (*B. vulgaris* provar. *conditiva*) и лободи (*Atriplex* spp.). Напад на шећерној репи ни на једном локалитету није био већи од 5%. Но, у будућности суво и топло време може допринети масовном размножавању ове штеточине а тиме и повећању штетности. Обична пепељуга је у условима Словачке значајан индикатор репине коренове ваши и омогућава лакше праћење бројности ове штеточине а тиме и потребу њене регулације. У току праћења појаве ове ваши констатовали смо скоро на сваком локалитету и њеног природног непријатеља — ларве врсте *Thaumatomyia glabra* (*Diptera: Chloropidae*).

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THE PHYTOSANITARY FORM AND FIGHTING MEASURES AGAINST DISEASES AND PESTS OF SUGAR BEET FROM REPUBLIC OF MOLDOVA*

ABSTRACT: Sugar beet is one of the most important agricultural crops in the Republic of Moldova. The North and Central regions have good enough pedoclimatic conditions. The genetic potential of sorts and hybrids can be created through the application of modern technologies in order to grow at least 32—35 tons/ha of sugar beet roots.

In the Republic of Moldova, sugar beet vegetates between 160 and 180 days in the first year and needs approximately an amount of 2400—2900°C, average of 15.3—15.4°C. Each phenological phase needs different temperatures: at least 4C° is necessary for planting and springing; an amount of 650°C is necessary for foliar apparatus; an amount of 1150—1800°C is necessary to grow the volume of roots and for sugar depositing the average of 2400 to 2600°C is necessary.

The mentioned temperatures ensure a normal development of sugar beet plants. If these temperatures fluctuate, the pathogens and pests are stimulated to develop. The most frequent diseases of sugar beet are: *Pythium de baryanum* H e s s e., *Aphanomyces cochlioides* D r e s c h., *Peronospora schachtii* F u c k., *Phoma betae* F r. *Cercospora beticola* S a c c., *Erysiphe communis* G r e v. f. *betae* J a c z., virosis — *Beta virus* 2, 3 şi 4 etc.

The main pests belong to the following categories: *Homoptera*: *Aphis fabae* S c o p. (fam. *Aphididae*), *Pemphigus fuscicornis* K o c h. (fam. *Pemphigidae*); *Coleoptera*: *Agriotes* sp. (fam. *Elateridae*), *Chaetocnema concinna* M. *Ch. breviuscula* Fld., *Cassida nebulosa* L. (fam. *Chrysomelidae*), *Atomaria linearis* S t e p. (fam. *Cryptophagidae*); *Bothynoderes punctiventris* G e r m., *Tanymechus dilaticollis* G y l l., *T. palliatus* F., *Psalidium maxillosum* F., (*Curculionidae*); *Lepidoptera*: *Agrotis segetum* D e n. et S c h i f f., *Authographa gamma* L. *Mamestra (Barathra) brassicae* L. (*Noctuidae*), *Loxostege sticticalis* L. (*Pyralidae*), *Gnorimoschema ocellatella* B o y d.; *Diptera Pegomyia betae* C u r t i s. (fam. *Anthomyidae*). *Heterodera schachtii* S c h m i d t (*Heteroderidae*).

The most recommended insecticides for fighting the pests are: Actara 25 WG, Actellic 50 EC, Arrivo 250 CE, Bastar 40 EC, Bi-25 Nou, Decis 2,5 EC, Decis Duplet 36 EC, Decis Forte 120 EC, Diazol 60 CE, Dursban 480 EC, Pirimor 50 WG, Pyrinex 250 ME, Sumithion 50 CE, Sharpei ME, Virin — OS, Zolone 35 EC.

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The most important fungicides recommended for fighting the diseases are: Derosal 50 SC, Fundazol 50 WP, Impact 25 SC, Oxiclorură de cupru WP, Privent 25 WP, etc. (D a - n i l o v and colab., 2003; *Prognoz rasprostraneniä…).

KEY WORDS: Fytosanitory condition, pathogens, pests, sugar beet, R. Moldova

INTRODUCTION

The development of sugar industry in the R. of Moldova began in the middle of the last century. This long period promoted significant expansion of areas allocated to sugar beet. However, the market economy, changes of the property and the form of the agricultural organization, instability on traditional foreign markets and financial crisis led to that in 90s, the sector of cultivation and processing of sugar beet is on the threshold of bankruptcy. The volume of raw material decreases from year to year and some factories are practically unable to work. The deep economic crisis in this sector risks to degrade into a general social crisis. As the sugar industry in the North of Moldova is the basis for maintenance of 80 000 workplaces, including many farmers who refuse to grow sugar beet because the local factories are processing the imported sugar cane. The processing of sugar cane is cheaper for the Moldavian factories. As a result, the Moldavian sugar is excluded from the list of freely exported products to Russia and Romania.

The areas covered with sugar beet in 2001 made 50 000 ha and in 2005, 32 000 ha. The areas decrease every year because of unstable economy, including sugar beet — one of the most labour-consuming cultures. The reason is the constant change of technology of its cultivation and the search for new approaches to develop the ways of protecting this culture from wreckers and illnesses. Besides, it is the most sensitive culture to damages, demanding special attention.

MATERIAL AND METHODS

Annual data on phytosanitary condition of sugar beet in the R. of Moldova have been collected from local information brochures about the protection of plants published by the republican service. The information is used by lecturers as lesson subjects like: agricultural entomology, the forecast and the signal system in plant protection.

RESULTS

In the Republic of Moldova, about 200 species of insects develop on beet and the greatest harm is caused by monophags and oligophags which have adapted to it, transferring from wild-growing *Chenopodiaceae*. Some poliphagus larvae have developed a plentiful nutrition reserve because of their vegetation since spring till late autumn. Sugar beet to a great extent can provide the development of one or several generations of the pests.

Planted seeds, during their germination and the developing roots are damaged by many wreckers living in the ground belonging to *Elateridae*, *Tenebrionidae*, larvae *Atomaria linerais* Step., larvae of *Scarabaeidae* and other families. In the process of further growth of a root crop, down to harvest, the underground part of plant is damaged by larvae of *Scarabaeidae*, *Curculionidae*, *Pemphigidae*. The upper parts (head) are damaged by caterpillars *Noctuidae*, beet leafminer. Because of the head damage of root, the plant has a lag in growth and develops abnormally and during the storage the damaged roots quickly rot.

Embryos of sugar beet and then young plants-up to 4—6 pairs of leaves — are damaged by *Bothynoderes punctiventris* Germ., *Tanymechus dilaticollis* Gyll., *T. palliatus* F., *Psalidium maxillosum* F. (*Curculionidae*); *Chaetocnema concinna* Marsh. *Ch. breviuscula* Fld. (*Chrysoemlidae*), *Opatrum sabulosum* L., *Blaps halophila* Fisch. (*Tenebrionidae*), *Agrotis segetum* Den. et Schiff., *Authographa gamma* L. (*Noctuidae*) and others. If the control is not made in time, crops are strongly weeded or often perish. The damages of embryos and young plants of sugar beet at small norms of seeding of the seeds applied at mechanized cultivation of sugar beet represent the greatest danger.

Vegetative plants, begining with 2—3 pairs of leaves are infested by *Aphis fabae* Scop. and damaged by larvae of *Noctuidae*, *Pyralidae*, *Gnorimoschema*. Damages of insects cause reduction of roots weight and sugar. The losses of roots can make 30—50 centner/ha and more and sugar decreases 1—3%. Species *Aphis fabae* Scop., besides direct harm is also a carrier of virus illnesses of sugar beet (jaundice, mosaic).

DISSCUSION

The phytosanitary condition of sugar beet for the 2001—2005 period:

Ord. Homoptera

Aphis fabae Scop. The areal of the wrecker gradually increasesd. However, long droughty periods and the presence of entomophags constrain the intensification of the wrecker multiplication. Especially it was visible in 2004 and continued in 2005. Migration on weeds and host-plants usually begins in August/September. It occurs because less favorable conditions for development of plant louse are created: reinforcement of leaves and lowered humidity. Migration of females on perennial plants can continue till October. In these places, the plant aphids are developing in mass due to long warm weather. Some data on such conditions are presented in table 1.

Table 1. Settling and number of *Aphis fabae* Scop. In 2001—2004 in R. Moldova

Species	Year				
	2000	2001	2002	2003	2004
Wintering of winter eggs	90,6	92,6	91,3	95,0	84,6
Infested areas, %	67,9	39,4	72,2	78,0	51,5
Infesed plants, %	7,5	7,4	15,6	21,8	5,1
Infested leaves, %	10,5	10,4	21,1	25,8—60	7,6

Pemphigus fuscicornis Koch. Beginning with 2000, the species has extended and caused damages in focus. Despite preservation of the urea size in previous years (29,6% of the area), the population of plants, due to intensive development of entomophags (1,2 exemplar/plant) and loss of deposits in July/August in the north part of the republic (from 155,8 up to 169,8 mm) decreased 2 times and before harvesting made 6,6%. In 2001, the droughty period came in July/August after long damp and caused later infesting of beet. These factors influenced the spreading of the pests which made 23,6%. Quick increase in ground temperature accelerated the development of *P. fuscicornis* Koch., which led to the excess of plants population 2 times in comparison with 2000 and made 13,0%. Simultaneously, the entomophags multiplicated and the average quantity made 1,6 exp/plant.

The development of *P. fuscicornis* Koch. on root crops of beet and root species of *Chenopodium* L. continued up to the end of September. The alternation of dry and hot weather with torrential rains in 2003 negatively affected the development of migratory larvae. Therefore, despite small expansion of the infested focuses to 35,8%, harmfulness decreased up to 3 times and made 4,1% of the populated plants. In 2003, the development and accumulation of *P. fuscicornis* Koch. occured in May/June on *Chenopodium album* L. in conditions of high deficiency of moisture in ground and high temperature of air. Sugar beet was infested by migratory larvae, as in 2002, in the second decade of July. In August, in conditions of hot weather and relative low humidity, the centers of distribution extended up to 34,4% of the area and damage increased up to 2 times, in comparison with 2002, making 9—20% of the damaged plants. Though for 2004, dangerous infesting of beet was predicted, especially on fields after corn or the ground infested by weeds, it did not happen. The unstable character of weather in the first half of vegetation period of beet negatively affected the development and distribution of *P. fuscicornis* Koch. This condition continues till nowadays. Avoiding the density of pest population will allow reducing the contaminations of fields.

Ord. *Coleoptera*

Elateridae and *Tenebrionidae*. There was a significant accumulation of larvae from *Elateridae* and *Tenebrionidae* family. The growth of number and damages of commercial crops was marked in the conditions of optimum combination by temperature and humidity during mass rise larvae in the top layers of ground in 2000. So the embryos of beet on 2,375 ha were damaged from 10,4 up to 20,3%. In 2001, the quick cold snap which came in the second half of March, burdened the rise of larvae into the top layers of the ground. During this period — March and April, 2001 — there was raised humidity of the ground and thus, the period was marked by their returned migration that affected the decrease in damage. Beet germs were populated on 69,8% of the area and caused the damage on 6,9% of plants against 88,1 and 10,3% in 2000, with the number exceeding the threshold of 39,2% of the populated area. Maximum damage of 18,4% was registered on 1,4 ha with the number of 7,5 exp/m^2.

Early warm spring in 2002 stimulated the rising of larvae into the top layers of the ground and the cold snap which came in III/03—I/04 was the reason of their backwards migration. Therefore, despite field population up to 71,0%, damaged beets embryos decreased and averaged by 4,0% (2001 — 6,9%), with the average number of 1,0 exp/m^2 (2002 — 2,3%) having exceeded the threshold level with only 5,8% of the populated area. The maximum number — 2,3 exp/m^2 was marked on 340 ha with the damage of 9,2%. On 90 ha of beet embryos received from toxic seeds, the density of larvae was high — 5,3 exp/m^2 — but the damaged plants were not revealed. The decrease in damage was marked on sunflower and corn as well.

In 2003, because of cold late spring the rise of larvae into the top layers of the ground began two decades later than the last year terms. On emerging embryos of beets, received from toxic seeds, the full destruction of larvae was observed. With the end of April, in conditions of sharp rise of temperature that caused fast drying of the ground, larvae migration into deeper layers of soil was observed. On beet, as well as on other cultures, the decrease in larvae damage was noticed in comparison with 2002.

In 2004, the rise of larvae into the top layers of soil had a stretched, non-uniform character. In some areas, because of low humidity, the larvae presence in soil was not fixed. The changed conditions after the last rains, in III/04—I/05 promoted mass rise and active larvae feeding on embryos of beet which was expressed in the increase in damage parameters in comparisin with the season of 2003. The harm on plants averaged 4,0% with the same number of 1,1 exp/m^2 on 44,2% of the area. Proceeding from it, in the view of water saturation with long-term weeds in 2005, the danger of shoot damage of these pests remained. Established during the autumn period, the high number of larvae from *Elateridae* and *Tenebrionidae* family, 60% in advanced ages was the reason of their mass damage, both on germs of sugar beet and on plants that are grown in greenhouse.

Curculionidae. In 2000, all species of weevil spread on beet. Their output from places of wintering coincided with average long-term data — in the second decade of April. The sharp cold snap in the first decade of May — minimum T°C = 2° — caused stretched settling of weevil on beet. The number of bugs on average was insignificant, 0,3—0,6 exp/m^2. However, their damage increased 2 times and made 9,9% of the damaged plants on 91,8% of the areas. The long dry period of autumn negatively affected the formation of wintering stock of *B. punctiventris* Germ. So, on 16,6% of the areas, the wrecker was generated in the stage of bug — 55% and larvae — 30%. Concerning the population on the areas under beet, *T. palliatus* Fabr. was significant — 40,1% of the area with average population of 0,5 exp/m² and bugs — more than 80%. The density of *T. dilaticollis* G y l l. was 0,4 exp/m² on 50,7% of the area. In 2001, the early output of bugs from places of wintering was caused by temperature of 10,20°C in March and the beginning of April. But, the unstable character of weather of the subsequent period lowered the activity of weevil. Therefore, the population on beet during the occurrence of embryos decreased up to 46,7%, *T. dilaticollis* G y l l and 46,2%, *T. palliatus* F a b r. The number of wreckers was kept at former level, up to 0,6 exp/m². Weather conditions negatively affected the development of *B. punctiventris* G e r m. which area of distribution was reduced 2,5 times and made 17,6% with the wrecker density of 0,4 exp/m². Cold weather, accompanied by weak intensification of illumination enabled active living ability of *Psalidium maxilosum* F. The population of germ of this species increased from 0,5 (2000) up to 16,9% in 2001. The density of bugs on m² was up to 0,4—0,8 due to individuals from diapause of the last year which increased simultaneously as well. Considering the degree of settling at heat approach and moisture presence during germination in the spring of 2002, the damage of weevil of all kinds raised.

In 2001, there was an expansion of the areas infested with all kinds of weevil. See table 2.

Table 2. Change of population and number of weevil in 2001—2004 in R. of Moldova

Species	Population %				Density/m²			
	2001	2002	2003	2004	2001	2002	2003	2004
Tanymechus dilaticollis G y l l.	46,7	54,5	33,1	80,3	0,6	0,3	0,7	1,1
Tanymechus palliatus F a b r.	6,2	52,0	43,4	56,7	0,5	0,2	0,9	1,0
Bothynoderes punctiventris G e r m.	7,6	24,4	33,8	34,3	0,4	0,3	0,6	0,5
Psalidium maxilosum F.	16,9	20,2	33,2	36,4	0,8	0,4	0,4	1,0

The reason of the changed number of these weevils are the sharp cold snaps during an output from places of wintering for 2000—2001. Also, the long droughty period during the autumn negatively affected the formation of wintering stock of *B. punctiventris* G e r m. Cold weather and weak intensification of illumination caused low capacity of development of *P. maxilosum* F. The second half of the year of 2002 was characterised by drought being replaced with torrential rains, which defined the character of wintering weevil stock.

In 2003, high temperature conditions in May — maximum temperature 30—33,40 — enabled active settling and feeding of bugs. Favorable weather conditions of the second half of vegetation and the autumn period positively influenced the formation of wintering weevil stock which were sent away into diapause basically in the imago stage, 83,8—90%, as the forecast of weevil in 2003 was positive because of satisfactory physiological readiness and factor of infesting bugs. Therefore, in 2004 the damage of all kinds of weevil in comparison with 2003 increased 2,7 times and averaged 27,4% of the damaged plants. In 2005, in the majority of areas, especially on fields where preliminary were long-term grasses or cereal grains, specific prevailing structures of *T.*

palliatus F a b r. and *B. punctiventris* G e r m. were expected. Their number in the host-plants exceeded the economic threshold of harmfulness 2 times due to diapaused individuals of the previous years and also because dry and hot weather strengthens their activity. The density of *T. dilaticollis* G y l l. simultaneously grows in a crop rotation where there preliminary was corn.

Atomaria linearis S t e p. In the of Republic of Moldova, the *A. linearis* S t e p., during many years achieved wide spreading. It occurs because of incomplete harvest of root crops of beet that helps bugs better development. In March, due to temperature increase of more than 5—7°C the awakening of bugs and settling on the remained root crops on old beets begins. In 2001, the greatest density of bugs on the populated root crop reached from 18,5 up to 102 exp/m^2 (table 3). However, this species depends on weather conditions and its development strongly oscilates. That is why, in 2001 the damage decreased 2 times in comparison with 2000 and the damaged plants reached 3,8%. The part of population remained in the same places for wintering for the next year. New generation of bugs migrate to soil in July/August and in September/October after, the deposits being dropped out, their autumn migration to surface begins. The majority of population remains on the same field for wintering and a part migrates into forest belts near old beet cultures on fields of long-term grasses. This continues till now a days.

Table 3. Change of population and number of *Atomaria linearis* S t e p. In 2001—2004 in the R. of Moldova

Index	Year				
	2000	2001	2002	2003	2004
Infesting, %	73,6—49	68,2	68,7	44,8	71,0
Number of rizocarp/m^2	1,5	1,3	1,4	1,6	1,5
Density, exp/m^2	15,2	18,5—102,0	12,7	3,9	14,7
Damage, %	7,9	3,8	4,0	2,8	3,7
Average number of cavities	1,6	1,7	1,5	1,4	1,5

Chaetocnema concinna M. Sugar beet beetle have reached general spreading on all kinds of beet. In the last 5 years, the number of beetles was the highest, up to 6,2 indivds/m^2, with the inspected areas up to 98,1%. During the years with dry and hot weather, the crop supports active pesting of beetles with high rate of damage, 3 times exceeding the medium pesting rate and making 33,7% of the damaged plants. The damage caused by flea beetles is presented in table 4.

Table 4. Damage caused by *Chaetocnema concinna* M. in 2001—2004 in R. Moldova

Index	Year				
	2000	2001	2002	2003	2004
Density of teritory, %	75,7	91,7	98,2	95,5	94,6
Density of bugs, indiv./m^2	4,3	6,1	5,0	3,5	10,0
Damage, %	33,7	26,3	18,2	16,4	23,5

According to data presented in table 3, it is visible that in the last 4 years, the area attacked by beetles mentained from 91,7% up to 98,2%. It is also followed by the damage of 16,4% in 2003 and 23,5% in 2004. This shows that this kind of species continues to cause essential harm to beet.

Cassida nebulosa L. For more than 8 years in dynamics of development, *Cassida nebulosa* has kept the recession of population. The pest is spread in focuses, basically on the littered sites and causes insignificant damage: 2,2—4,5% of the damaged plants and the number from 0,3 up to 1,1 exp/m^2.

Ord. *Lepidoptera*

Agrotis segetum Den. et Schiff. The wintering of the pest passed safely — 89,5%. The conditions for pupae passage were succesful. That is why the fruitfulness of females that wintered averaged 420 eggs. High temperature conditions — 34,5°C — on the background of low humidity — 40—50% — negatively affected the passage of eggs and the eclosion of the caterpillars of the first generation, which was noticed with low number on all fields with crop rotation. From the inspected fields, they had the greatest distribution on sugar beet and tobacco in northern zone of the republic, after the deposits being dropped out. The density of caterpillars above the economic threshold of damage of more than 2 individ/m^2 was observed on only 13,2% of the populated areas. Also, the density of wintering caterpillars was high on sugar beet, from 1,7 up to 2,5 individ/m^2. In 2001, 0,7 individ/m^2 were noticed wintering on 36,2% of fields with sugar beet and other cultures. As the conditions were favorable — warm and long autumn — the most part of caterpillars (66,7%) finished their development at the age of 5—6. This positively reflected on the passage of wintering. In 2002, because of low humidity of air (54%) in combination with high temperatures (30,3°C), deposited eggs of catepillars of younger age dried up and died. Therefore, the population of the first generation was formed mainly due to the latest deposits. From here, the population of cultures in 2002 as well as in 2001 remained of low level. Adverse weather conditions of the winter period of 2002—2003 caused the destruction of 22,8—50,0% of caterpillars, basically middle aged. However, the weather conditions of autumn 2003 caused the end of caterpillars feeding, leaving 78,9% of individuals with the age of 5—6 and density of 0,8 individ/m^2 for wintering on 47,5% of the area. Thus, in 2004 mass multiplication of the pest was predicted. The forecast was also justified with the fact that the survival rate of caterpillars during winter diapausis was high — 83,3—100%. In 2005, the unstable weather and the return of cold weather in April constrained the pupae of the pest, which came to an end in the first half of the month. The flight of individuals that passed wintering began at SÇT 220°C and had a stretched character.

Mamestra (Barathra) brassicae L. In 2000, the pesting average on sugar beet made 4,8% of plants (5,2% in 1999) on 55,6% of the areas (69—3%, 1999) with the number of 1,2 exp/on the populated plant (1,5, 1999). In 2001, the damage of caterpillars of the second generation on beet remained at the last year level, i.e. low. For the autumn/winter period 2001—2002, 83,6% of pupae wintered. The number of pests during the season of vegetation increased. On sugar beet, on 35,6% of the area, the pested plants made 8,3% against 4,8 in 2001. Above the threshold number, it was marked on 342 ha. The autumn period, characterized by moderate temperatures and humidity promoted successful end of the pest development. In soil excavations on fields of cabbage and beet, the number of wintering pupae was about 0,6 exp/m^2 on 32,5% of the surveyed area. The average weight of pupae from fields with beet made 420 mg and with cabbage 489 mg (600 mg is the maximum) which corresponds to good survival rate of pupae and high fruitfulness of females. Such parameters predicted the increase in number of the population in 2003. The forecast was correct and the area of the pest extended on 49,3% against 26,3% in 2002. On 82,2% of the area, 22,9% of plants were populated (35,7%, 2002) and the number was 2,3 exp/plant (1,6, 2002). Long warm autumn promoted successful end of caterpillars feeding and formation of a wintering stock which considerably exceeded last years, having made 2,3 copy of pupae on 1 m^2 (0,6, 2002) on 55,1% from the surveyed total area (32,5%, 2002). Concerning sugar beet and cabbage, it is the area that made 10,3 thousand in ha. The maximum number of pupae — 3,2 exp/m^2 — is revealed on 970 ha with beets. The weight of pupae was within the limits of 453—505 mg which corresponds to good survival rate and expected high fruitfulness up to 1700 eggs. Proceeding from it, in 2004, in the first generation at an optimal combination of heat and moisture the mass duplication of the pest was kept. Significant wintering number and high percentage of survival rate of pupae (87,4%) caused the potential of mass duplication of the pest in the first generation, as it was predicted in 2003. On sugar beet population, it made 5,1% (4,3%, 2003) on 53,8% of the area. In the second generation, the humidity deficiency (K = 0,3—0,5), during the critical period for scoop development (a stage of a pupae) defined the decrease in intensification of pest duplication. The damage on sugar beet made 5,7% of the areas and it was 2—3 times below the level of 2003. There was also a decrease in number of caterpillars from 1,7—2,3 in 2003 up to 1,2—1,7 in 2004. The surface of the populated area also decreased up to 62,5%. In 2005, because of high percentage of wintering pupae from 2004 (90%), the pest has greater success in multiplying on many cultures, including sugar beet.

Gnorimoschema ocelatella B o y d. A slight warming of climate of 1,2—4,0°C favourises an earlier development of all 3 generations of *G. ocelatella*. Having a high sensitivity on warmth, the occurrence of mines with caterpillars of the first and second generations, in comparison with average long-term data, in 2000—2004 was fixed on the decade earlier in I/07 for the second generation and I/08 for G_3. High temperatures of the given period promoted high population of beet and formation of high biological reserve of the pest. Only in 2001 cool rainy weather in May/June lowered the intensity of duplication of the first 2 generations of *G. ocelatella* which damage was insignificant — 4,3% of the damaged plants. However, the established dry, warm weather in July/August favourised the development of the third generation. In the next year, the area of the damaged plants was from 53,3—55,4% in 2002—2003 up to 35,3% in 2004 and harmed 5,1—6,1%. The recession of the damaged plants occured because of unstable character of weather in May/June 2004. In 2005, it has kept focus distribution and insignificant harm.

Heterodera schachtii Schmidt — the area of distribution of the pest has extended since 2002, covering new areas each year. Losses of plentiful deposits and moderate temperatures of air 19—23°C have developed favorable conditions for development and multiplication of nematodes. The first host with more than 15% of damage was noted on 175 ha of beet. On this site, the weight reduction of root crops was observed. Intensive introduction of larvae in root crops of sugar beet continued in August/September. Considering the fact that eggs and larvae of nematodes are inside a cyst and are protected from adverse conditions maintaining viability in ground till 4—8 years, in the subsequent year the centers of infection with beet nematodes will extend at a favorable combination of heat and moisture and infringement of a crop rotation. In struggle with beet nematodes, the destruction of weeds especially *Cruciferae* and *Chenopodiacae* is extremely important. Also, the lengthening of break between repeated cultivation of beet with 3 till 5—6 years will lower the number of nematodes for more than 3 times.

Pathogens

The complex of pathogens: *Pythium debaryanum* Hesse., *Aphanomyces cochlioides* Dresch., *Peronospora schachtii* Fuck., *Phoma betae* Fr., *Rhizoctonia violacea* Tul., *Fusarium* sp. In the last 5 years, the percentage of damaged plants increased almost 2 times and made 5,8—15,5%. Intensive rains during the third decade of April, 2000 condensed the ground. It provoked the vigorous activity of soil pathogens, which caused the infection of embryos of beet on 50,8% of the areas. Also, deposits of the end of July renewed the activization of mycosis of *Fusarium, Aphanomyces, Phoma*. In September, the display of pathogens and forms of various anomalies of root crops was later observed. During the development of germs in 2001, plentiful deposits and downturn of ground temperature improved conditions of activization of other soil patogenes, *Pythium, Phoma, Rizoctonia, Peronospora*. These occured on the fields with low agrotechnical level and late destruction of the surface core because of the rain insufficiency. Thus, damages of germs exceeded 25% in 2001, 86,4% in 2002, 58,3 in 2003. In 2004, the display of disease began late — in the third decade of April. The absence of deposits and low daily temperatures (12,1—15,2°C) constrained the development of soil patogenes. Despite the fact that the area remained as former, as in 2003, the damage of the patogens increased 2,2 times and made from 7,2 up to 30% of the plants in 2004. The similar situation occurs in 2005.

Cercospora beticola Sacc. Droughty conditions of May/June, 2000 constrained the infection of beet with *C. beticola* Sacc. for a month. The occurrence was observed in the first decade of July but with a weak degree of development. Mass character of distribution was observed in September. The area made 96,2% and the plants 21,3%. The heat of air in August lowered plant turgor which promoted mass defeat of beet oby *C. beticola* S a c c., considering full dependence of *C. beticola* S a c c. on humidity and temperature.

Erysiphe communis G r e v. f. *betae* J a c z. During the last 10 years, in 2000 pathogens captured the greatest area — 95,7%, with the average of infected plants — 44,6%. In 2001, the areas affected by pathogenicity made 92,1% with the same damage as in 2000 — 42,9%. Dry, hot weather with small deposits in June/July, 2002—2003 promoted the infection of beet with *E. communis* G r e v. However, plentiful rains at the end of July lowered the pathogene activity. Therefore, the distribution of parameters and the damage decreased in comparison with 2001 and made 86,4% of the infected area. In 2003, it made 58,3%. In the subsequent years 2004—2005, the areas of infection have again increased 2 times — 97,7%.

Pesticides recommended for controlling pest organisms in R. Moldova.

Insecticides: Decis Forte 120 EC; Lamdex 5 EC; Bastar 40 EC; Actellic 50 EC; Dursban 480 EC; Zolone 35 EC; Arrivo 250 EC; Decis Forte 120 EC; Actara 25 WG; Lamdex 5 EC; Diazol 60 EC; Dursban 480 EC; Actellic 50 EC; Bi-58 Nou; Sumithion 50 EC; Bastar 40 EC.

Fungicides: Scor 250 EC; Alto Super 330 EC; Derosal 50 SC, Privent 25 EC; Fundazol 50 WP; Impact 25 SC.

CONCLUSION

1. In the Republic of Moldova, about 200 kinds of harmful organisms develops on a sugar beet.

2. The greatest and constant harm is caused by the insects from *Curculionidae* family (*Bothynoderes punctiventris* G e r m., *Tanymechus dilaticollis* G y l l., *T. palliatus* F., *Psalidium maxillosum* F.) *Chrysomelidae* family (*Chaetocnema concinna* M. *Ch. breviuscula* F l d.), *Aphididae* (*Aphis fabae* S c o p.) and *Pemphigidae* (*Pemphigus fuscicornis* K o c h.) families.

3. The most frequent diseases of sugar beet are: *Pythium debaryanum* H e s s e., *Aphanomyces cochlioides* D r e s c h., *Peronospora schachtii* F u c k., *Phoma betae* F r. *Cercospora beticola* S a c c., *Erysiphe communis* G r e v. f. *betae* J a c z., etc.

4. The most recommended insecticides for fighting the pests are: Actara 25 WG, Actellic 50 EC, Arrivo 250 CE, Bastar 40 EC, Bi-25 Nou, Decis 2,5 EC, Decis Duplet 36 EC, Decis Forte 120 EC, Diazol 60 CE, Dursban 480 EC, Pirimor 50 WG, Pyrinex 250 ME, Sumithion 50 CE, Sharpei ME, Virin — OS, Zolone 35 EC.

5. The most recommended insecticides and fungicides are: Scor 250 EC; Alto Super 330 EC; Derosal 50 SC, Privent 25 EC; Fundazol 50 WP; Impact 25 SC.

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ФИТОСАНИТАРНЕ МЕРЕ БОРБЕ ПРОТИВ БОЛЕСТИ И ШТЕТОЧИНА ШЕЋЕРНЕ РЕПЕ У РЕПУБЛИЦИ МОЛДАВИЈИ

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Резиме

Шећерна репа је један од најважнијих пољопривредних усева у Републици Молдавији.

Северна и централна област имају доста повољне педоклиматске услове. Генетски потенцијал сорти и хибрида може, кроз примену модерних технологија, да омогући гајење са приносом бар 32—25 тона/ha корена шећерне репе.

У Републици Молдавији развој шећерне репе у првој години вегетације траје између 160 и 180 дана и потребан јој је приближан износ 2400—2900°C, у просеку 15.3—15.4°C. Свака фенолошка фаза захтева другачије температуре, за сетву и ницање неопходно је бар 4°C; за развој листе масе је неопходна количина од 650°C; за обим раста корена неопходна је количина 1150—1800°C; а за депозит шећера неопходно је од 2400 до 2600°C.

Горе поменуте температуре обезбеђују нормалан развој биљке шећерне репе. Уколико ове температуре варирају, стимулише се развој патогена и штеточина. Најучесталији патогени шећерне репе су: *Pythium de baryanum* H e s s e., *Aphanomyces cochlioides* D r e s c h., *Peronospora schachtii* F u c k., *Phoma betae* F r. *Cercospora beticola* S a c c., *Erysiphe communis* G r e v. f. *betae* J a c z., virosis — *Beta virus* 2, 3, 4, итд.

Главне штеточине припадају следећим категоријама: *Homoptera*: *Aphis fabae* S c o p. (fam. *Aphididae*), *Pemphigus fuscicornis* K o c h. (fam. *Pemphigidae*); *Coleoptera*: *Agriotes* sp. (fam. *Elateridae*), *Chaetocnema concinna* M. *Ch. breviuscula* F l d., *Cassida nebulosa* L. (fam. *Chrysomelidae*), *Atomaria linearis* (fam. *Cryptophagidae*); *Bothynoderes punctiventris* G e r m., *Tanymechus dilaticollis* G y l l., *T. palliatus* F., *Psalidium maxillosum* F., (*Curculionidae*); *Lepidoptera*: *Agrotis segetum* Den. et S c h i f f., *Authographa gamma* L. (*Noctuidae*), *Loxostege sticticalis* L. (*Pyralidae*), *Gnorimoschema ocellatella* B o y d.; *Diptera Pegomyia betae* C u r t i s. (fam. *Anthomyidae*).

Најчешће препоручивани инсектициди за сузбијање штеточина су: Actara 25 WG, Actellic 50 EC, Arrivo 250 CE, Bastar 40 EC, Bi-25 Nou, Decis 2,5 EC, Decis Duplet 36 EC, Decis Forte 120 EC, Diazol 60 CE, Dursban 480 EC, Pirimor 50 WG, Pyrinex 250 ME, Sumithion 50 CE, Sharpei ME, Virin — OS, Zolone 35 EC.

Најважнији фунгициди који се препоручују за сузбијање болести су: Derosal 50 SC, Fundazol 50 WP, Impact 25 SC, Bakarni oksihlorid WP, Privent 25 WP, итд.

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SOLAR ACTIVITY INFLUENCE TO THE NUMEROUSNESS DYNAMICS OF *BOTHYNODERES PUNCTIVENTRIS* GERM. IN VOJVODINA*

ABSTRACT: In the region of Vojvodina, sugar beet weevil (*Bothynoderes punctiventris* Germ.) is the most important sugar beet pest. Therefore, it would be of great practical benefit if we could establish some regularity in their population dynamics, if it exists and then organize the control of this pest more successfully.

During the period of 1961—2004, in Vojvodina, the population density of *B. punctiventris* was monitored. The annual average of population density varied between 0 and 15 insects per square meter. Analyzing the obtained data it was noticed that there existed a certain periodicity of population outbreaks (maximal densities), approximately of 11 years. Regarding the fact that the solar activity, known as solar flux (observed at 2800 MHz) has a similar periodicity, a statistical processing in the paper of the collected data (periodograms, cross periodograms /real and imaginary ones/, cross densities, cross quadratures, cross amplitudes, squared coherencies as well as cross correlations) was carried out.

Inter alia, it was concluded that the population outbreaks of *B. punctiventris* follows the maximal solar activity (known as solar flux on 2800 MHz), with a lag of seven years.

KEY WORDS: solar activity, *Bothynoderes punctiventris* Germ., population dynamics

INTRODUCTION

The sugar beet has been attacked by a large number of pests. The most important one is sugar beet weevil (*Bothynoderes punctiventris* Germ.). It often caused damages in the Middle and Eastern Europe during the XX century, so it was studied by many scientists. Some of the well known were: B.

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Gróf, G. A. Manninger, L. Pintér, S. Zsembery, E. V. Zverezomb-Zubovski, O. I. Petruha, E. N. Žitkovič, V. P. Fedorenko, V. Bogdanov, F. Manolache, O. Auerach, P. Steiner, N. Tielecke, D. Čamprag and others. Monography concerning this pest was published (Č a m p r a g, 1984) in our country. In Ukraine, F e d o r e n k o (1998) studied the harmful insects and their natural enemies on sugar beet, in detail.

Abiotic and biotic factors, such as soil type, solar activity, climatic influences, quantity and quality of plant hosts, physiological conditions of the pest, natural enemies of the pests, agricultural activity of the mankind, influence to the pest population. In the natural circumstances, the fluctuations of the insect abundance, according to V i k t o r o v (1968), has certain limits, specific for some species and is carried out automatically. The rational organization of combat against pests is possible, emphasized the cited author, only by knowing the mechanism of the natural regulation of their abundance.

B e l e c k i (1986) represents the conception of the cyclical dynamics of the pest population, based on dependency of the biosphere, biocenosis and pests population on cyclical variations of the solar activity. The cited author carried out an analysis of population outbreaks for approximately 70 species of harmful insects in Ukraine (among which were sugar beet pests) over the period of 130 years. He found the coincidence of the most massive occurrences with strong fluctuations of the solar activity in a cycle of 11 years.

T r i b e l j (1990) emphasized that among abiotic factors (which affect the growth of the insect populations) one must indispensably insert not only temperature and precipitations, the solar radiation, but its cyclical variations, the electromagnetic fields of the solar system and of our planet, with their anomalies, the atmosphere, its gradients and other elements as well.

PERIODICAL PHENOMENA are events that occur after the same periods, which then have the same intensities. But, there are others, which do not have the same rhythm and do not always have the same dimensions in their periodical changing. We call such ones QUASIPERIODIC PHENOMENA.

There are different occurrences on the Sun which are visible, but some of them are hidden — these ones, such as solar flux may be observed by using various instruments. On the basis of such measurements we may computerize them and get some useful results.

DATA AND PROCESSING METHODS

The study of *B. punctiventris* population dynamics in Vojvodina (the northern part of Serbia) has been carried out during the period 1961—2004. This species spend the winter as adult in the soil of fields after sugar beet. For collecting the insect material, during September and October, the surveying of soil has been used. During a period of 44 years, in average, 75 fields after sugar beet have been inspected annually. On large farms, one sample in each two hectares, 0.25 m^2 in size (50 x 50 cm, 50 cm deep) was taken. The digged soil was inspected on the field, all the specimens of the *B. punctiventris* collected and later processed in the Entomological laboratory of the Faculty of Agriculture in Novi Sad. The abundance per m^2 was established.

There are two methods for data processing: the probability and the statistical one. We used the second type here. Using the so-called SPECTRAL DECOMPOSITION THEOREME which states: "That the energy or variance, of any time series, may be separated into contributions of statistical independent oscillations with different periods (frequencies)", we processed the obtained data. Each summit of the spectral function graph, PERIODOGRAM stands for an independent vibration. The sum of the so-called HARMONICS forms the whole observed phenomena. The highest top is the FUNDAMENTAL HARMONIC or the GENERAL PERIOD (FREQUENCY). The others are according to falling values, the FIRST, SECOND, etc. HIGHER HARMONICS (OVERTONES).

It was then observed which harmonics, of the both series, had the same period (made pairs — the cause and the result). Those belonging to the pests should form "echoes" of the corresponding solar pairs.

Then, we supposed that we were dealing with two stationary time series, X and Y and we wanted to know to what extent we may use the past of the series X to predict the future of the series Y. Here, as the criterion, we used the CROSS CORRELATIONS. They give, if there is one, a correlation of the corresponding lag of Y series behind the X series.

The existing influence was confirmed by means of: CROSS PERIODOGRAMS (IMAGINARY AND REAL ones). CROSS QUADRATURE, CROSS DENSITY, CROSS AMPLITUDE and SQUAERED COHERENCY.

Following data were used:

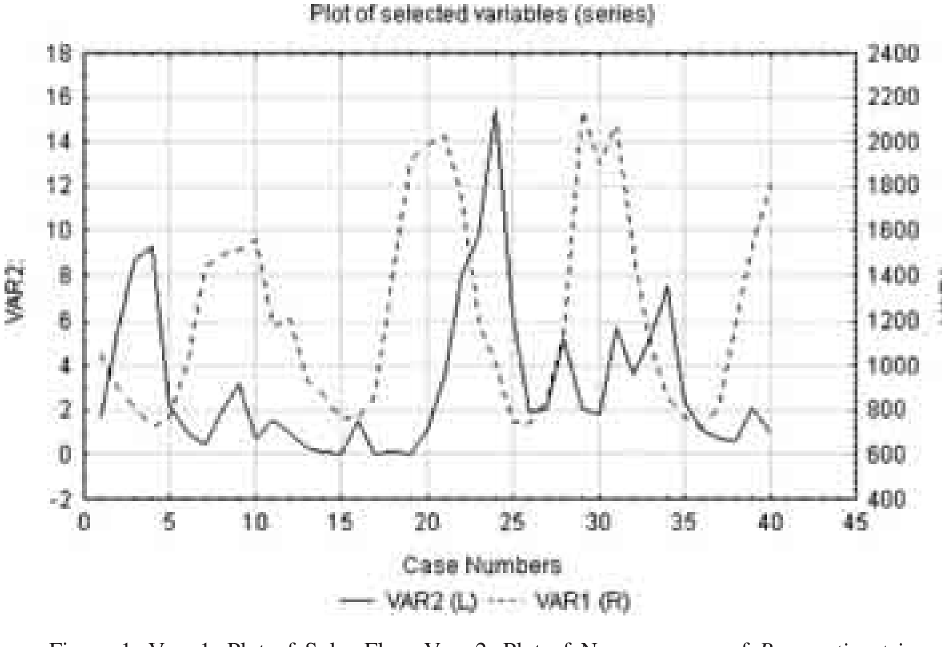

Figure 1. Var. 1, Plot of Solar Flux; Var. 2, Plot of Numerousness of *B. punctiventris*

Time series for the SOLAR ACTIVITY (yearly means):

X, Var 1 — ADJUSTED FLUX FROM THE ENTIRE SOLAR DISK AT THE FREQUENCY OF 2800 MHz (10,7 cm), in units of 10, the 22 Joules/second/square meter/Hertz. Each number was multiplied by 10 to suppress the decimal point (Figure 1). The adjustment means that they are refined for the fluctuations from the changing sun-earth distance; further, they are reduced for antenna gain, uncertainties and reflected from the ground in waves. These data were published by the National Geophysical Data Center, Boulder, Colorado, USA.

Time series for POPULATION DYNAMICS OF SUGAR BEET PESTS (yearly means):

Y, Var 2 — POPULATION DYNAMICS OF BOTHYNODERES PUNCTIVENTRIS in Vojvodina in individuals per square meter in a year (Figure 1). Both series started with 1961 and finished with 2004 year.

RESULTS AND DISCUSSION

Population dynamics of the *B. punctiventris* during 44 years in Vojvodina is shown in Figure 1. The population density varied between 0 and 15 insects per square meter. Before analyzing the solar activity influence on population dynamics of sugar beet weevil, it is useful to make some comments about the influence of air temperature and rainfall to the reproduction of this pest.

The higher temperature has more influence on the population density of sugar beet weevil than the precipitations, i.e. droughts. Two-year categories were analyzed: the first one with a great density of pest (1961—1964, with 6.3/m^2 and 1981—1995, with 5.2 insects per m^2) and the second with lesser density (1961—1980, with 1.0/m^2). In the period with high appearance of *B. punctiventris* the mean air temperatures were: 14,1°C (April to May), 18,1°C (May to June) and 17,9°C (July to September), while in the period with lower incidences, air temperatures for the mentioned months were: 13.5°C, 17.7°C and 17.1°C.

Between the population density of *B. punctiventris* and the quantities of precipitations, a negative correlation was established. During the 1970s, with a lot of rainfalls in growing season and only one year with drought, only 0.6/m^2 of *B. punctiventris* in average were ascertained. In the next decennium (ninth), with five years of drought and less precipitation during the vegetation, the density of pest was 5.6/m^2 on the whole.

Belecki (1986) studied the population outbreaks of *B. punctiventris* in Ukraine, during the period of 130 years (1854—1984), depending on solar activity. The relative frequency of massive occurrence was 41% in the years of maximal sunspot numbers, Wolf numbers, 48% a year after and 19% over other years.

PERIODOGRAM for the X series (Figure 2), ADJUSTED FLUX FROM THE SOLAR DISK OF 2800 MHz has *eight relative maxima.* This fact may be interpreted in the following way: this function has eight independent basic vibrations. *The fundamental harmonic has a period of 10.00 years (88.67% of*

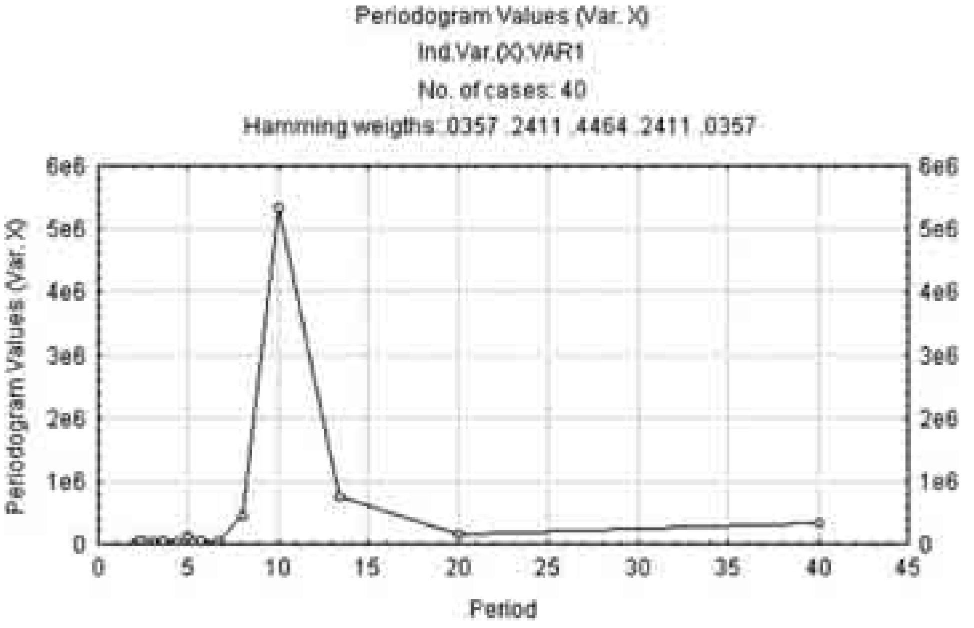

Figure 2. Periodogram of Solar Flux

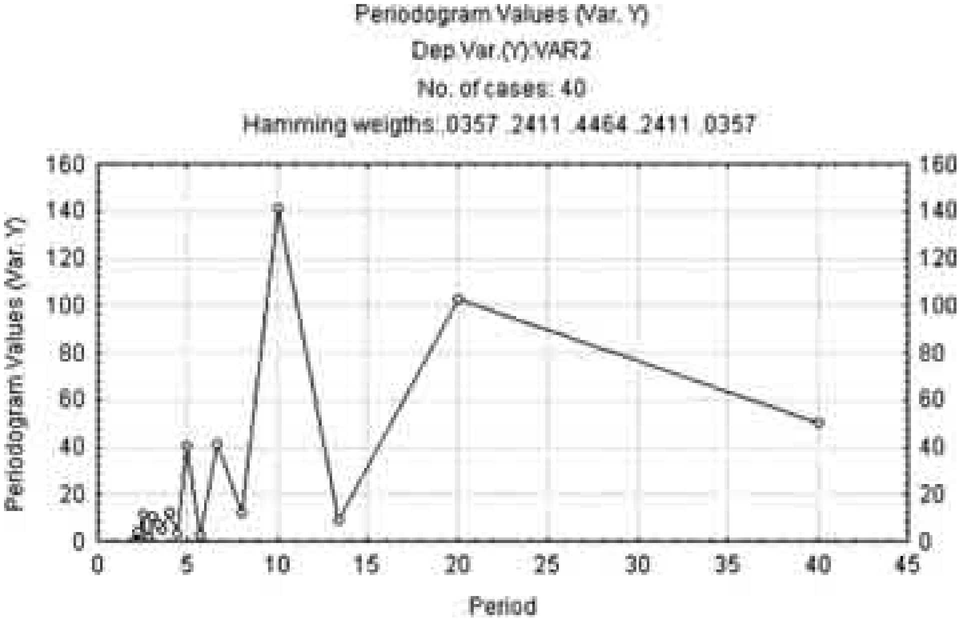

Figure 3. Periodogram of Numerousness of *B. punctiventris*

the whole). That is the period of lasting of the mean period of the solar spot magnetic polarization, after which it changes to the opposite pole. The first higher harmonic has the period of 40.00 years (5.60%). The second overtone has the period of 5.00 years (1.86%). The third higher harmonic has the period of 2.35 years (1.14%). The fourth overtone has the period of 2.11 years (0.80%). The fifth higher harmonic has the period of 3.64 years (0.79%). The sixth overtone has the period of 2.67 years (0.75%). *The seventh overtone has the period of 3.08 years (0.38% of the whole).*

PERIODOGRAM for the Y series (Figure 3), series for the pest *B. punctiventris* has also *eight relative maxima*, meaning that it is formed of eight independent, fundamental oscillations, as well as the former one. *The fundamental harmonic has the period of 10.00 years (38.71% of the whole).* The first overtone has the period of 20.00 years (28.20%). Exactly as the mean of the complete polarization of the solar spots lasts, the time when they again take the same pole (on a solar hemisphere, northern or southern one). The second higher harmonic has the period of 6.67 years (11.41%). The third overtone has the period of 5.00 years (11.05%). The fourth overtone has the period of 4.00 years (3.42%). The fifth higher harmonic has the period of 2.50 years (3.16). *The sixth overtone has the period of 3.08 years (2.92%).* The seventh higher harmonic has the period of 2.22 years (1.12% of the whole).

Comparing these two periodograms we notice that they have *two identical overtones.* To the fundamental harmonic of the solar activity corresponds the fundamental harmonic of the pest density and to the seventh overtone of the solar activity corresponds the sixth overtone of the pest density. This fact

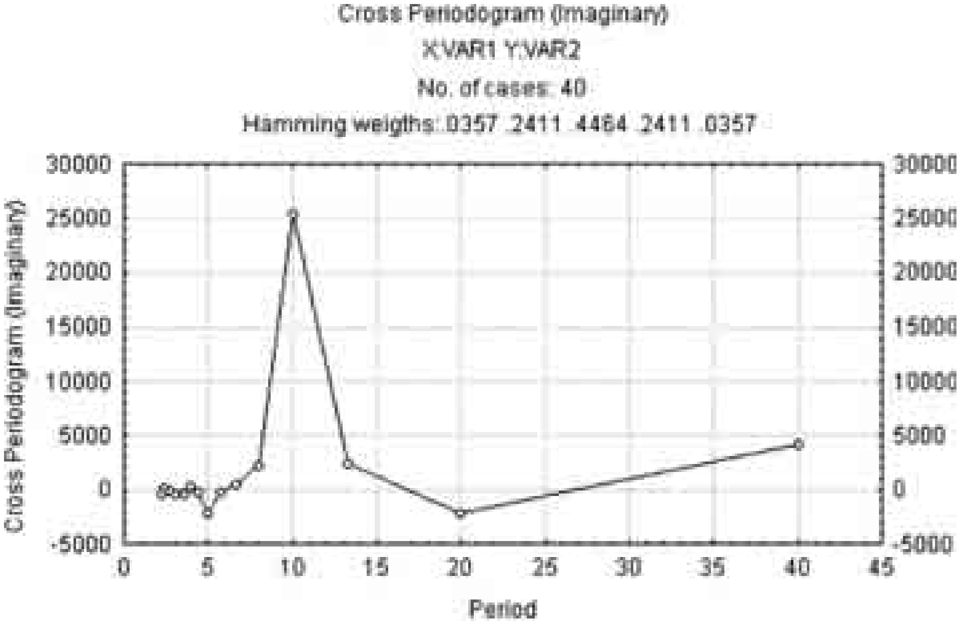

Figure 4. Cross Periodogram (Imaginary Part)

is a good confirmation for the existing influence. In other words: 89.05% of the solar activity has "echo" in 41.64% of the whole in the series for the pest.

Furthermore we conclude, using the BIVARIANT SPECTRAL ANALYSIS that there really exists a strong influence of the sun to the abundance of *B. punctiventris*.

Let us count up the other confirmations of our statement.

IMAGINARY PART OF THE CROSS PERIODOGRAM (Figure 4) has for 10.00 years a maximum maximorum of 25490! The next maximum has the value of only 4122!

REAL PART OF THE CROSS PERIODOGRAM (Figure 5) has an extraordinary minimum minimorum, for the period of 10.00 years, of (–10240). The next, according to its value, minimum is only (–1097)!

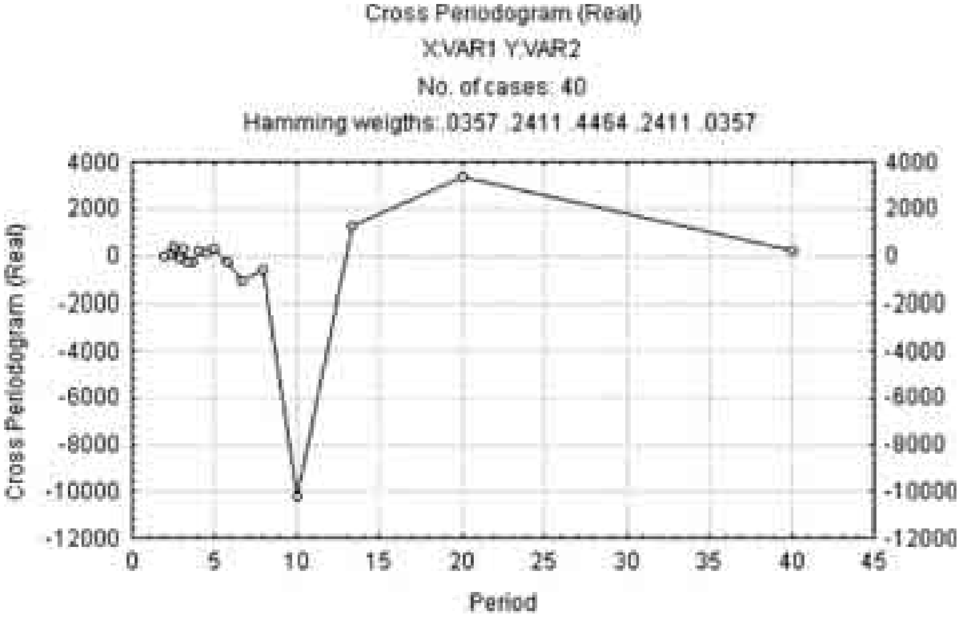

Figure 5. Cross Periodogram (Real Part)

Let us emphasize that in the first case the maximum maximorum and in the second case the minimum minimorum are the crucial ones!

CROSS (QUADRATURE) DENSITY has for the period of 10.000 years a maximum maximorum with the value 13162. The next relative maximum is only 1032!

One more confirmation for the existence of pest abundance dependence on solar activity is given by the QUADRATIC (SQUARED) COHERENCY (Figure 6). Its maximum maximorum of 0.879953 stands for the period of 10.00 years. We must here remember that the total connection of any two series has the value of 1.00000 and we got a relatively proximate value!

It remains to establish if there is any time lag between the two series considered. This fact gives the CROSS CORRELATIONS. From the numerical ta-

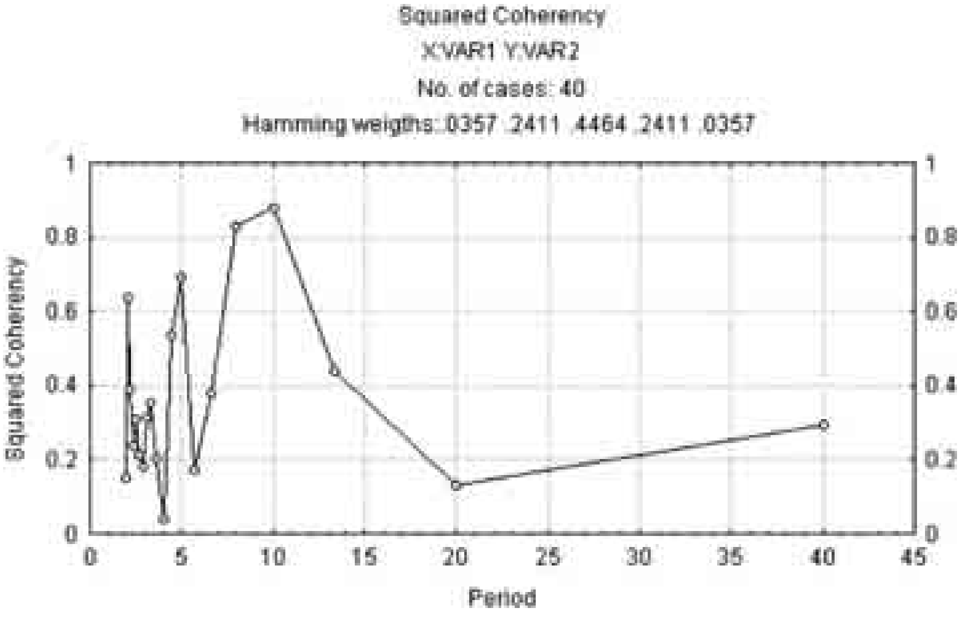

Figure 6. Squared Coherency

ble we may conclude that the population density of pest, *B. punctiventris*, has a maximum (outbreak) 7 years after the maximum of the solar flux. The minimum density has no significant expression.

Looking at the Figure 1, we may conclude that if we move along the horizontal axis of the graphic, for the Var 1 (solar flux), for 7 years we will get a better coincidence!

Planetary population outbreaks of different pests (*B. punctiventris*, *Eurygaster integriceps*, *Anisoplia* spp., *Calliptamus italicus* and other locust, *Loxostege sticticalis*, *Scotia segetum*, *Autographa gamma*, *Mayetiola destructor*, *Oscinis frit*, *Lymantria dispar*, *Cydia pomonella*, different rodent etc.) were registered during the years 1909—1912, 1924—1925, 1937—1942, 1950—1958 (B e l e c k i, 1986).

B. punctiventris presents the permanent member of sugar beet agrocenosis in the area of its appearance in Ukraine. Its density varies much along years. The massive occurrences replace depressions of short duration, reaching the level under economical threshold of damage. Massive occurrences have been recorded over the following years: 1851—1855, 1868—1869, 1892—1893, 1897—1901, 1904—1906, 1928, 1930, 1937—1940, 1947—1949, 1952—1957, 1984—1986 (T r i b e l j, 1990).

Population outbreaks of *B. punctiventris* in Serbia (Vojvodina) were registered particularly in the years 1949—1950, 1952, 1955, 1961—1964, 1982—1983 (Č a m p r a g, 1984). Except in the period of 1961—1964, there is enough similarity with outbreaks of the same pest in Ukraine.

Comparing the zone of the permanent damage provoked by the same pest with the chart of geomagnetic anomalies, it has been shown that the first encircles the regions with weakened tension of the magnetic field (T r i b e l j, 1990).

By comparison of the mass reproduction of *B. punctiventris* with the so-called Wolf, or relative sunspot number,

$$W = k\ (f + 10\ g),$$

where *g* represents the number of sunspot groups, *f* the total number of their component spots and *k* is a constant dependent on the estimated efficiency of and also the equipment used by a particular observer; it has been concluded that it coincides with the 11-year period of solar activity, which is characterized by low and medium activity, that is the period when the Wolf number, in the years of maximum has the values 70—100 and 100—140. At the time of low solar activity, intensive multiplying of *B. punctiventris* lasts 4—5 years and encircles the maximal territory. In the 11-year cycles, with average solar activity, the mass multiplying of this pest lasts 2—3 years.

During the period 1851—1920, the massive appearances of *B. punctiventris* occurred in the years of the reduced solar activity. Through 1920—1940 this was ascertained during the decline of the solar activity, although somewhat nearer to the maximum and over 1952—1957, the massive appearances were during the raise of the solar activity and at that time this pest spread over the largest territory in 1957 (the relative sunspot number was the greatest then and had an amount of 200.8). In the paper, published in 1990, S. A. Tribelj cited that *B. punctiventris* was in depression in Ukraine, over the last 20 years, on the most of the areas of its harmfulness.

CONCLUSION

According to the constructed periodograms and other graphs, we may conclude that a causal connection exists between time series for ADJUSTED FLUX FROM THE ENTIRE SOLAR DISC AT A FREQUENCY OF 2800 MHz (10.7 cm) on the one hand and the time series for the POPULATION DYNAMICS OF *BOTHYNODERES PUNCTIVENTRIS*, on the other. That fact is confirmed by means of cross periodograms (imaginary and real ones), cross (quadrature) densities, cross amplitudes and quadrature coherencies, which exist between cited two time series. So, the population outbreaks of *Bothynoderes punctiventris*, follows, after a lag of seven years, the maximal solar activity, measured as the flux on 2800 MHz (10,7 cm). In other words, the maximal density of this pest will be reached seven years after the maximal flux of the solar activity on the corresponding wavelength. The minimal abundance has no apparent expression!

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УТИЦАЈ СУНЧЕВЕ АКТИВНОСТИ НА ДИНАМИКУ БРОЈНОСТИ *BOTHYNODERES PUNCTIVENTRIS* G E R M. У ВОЈВОДИНИ

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Резиме

У подручју Војводине, током XX века, репина пипа (*Bothynoderes punctiventris* G e r m.) је представљала најважнију штеточину шећерне репе и често причињавала велике штете. Због тога би било од велике практичне користи да се установи нека закономерност у динамици бројности *B. punctiventris*, уколико постоји, како би се благовремено саопштила дугорочна прогноза степена њене појаве и организовало сузбијање ове опасне штеточине.

У Војводини се, од 1961, сваке јесени установљава бројност *B. punctiventris*, прегледом земљишта поља где је гајена шећерна репа. Током протеклих 45 година сваке године прегледано је у просеку око 75 поља. По појединим годинама установљено је од 0 до 15 јединки по m^2.

Анализом добијених података запажено је да се јавља извесна периодичност од око 11 година. С обзиром на то да је отприлике исто толика и она код Сунчеве активности, зване флукс или проток (мерена на 2800 MHc), у раду је спроведена упоредна статистичка обрада (периодограми, унакрсни периодограми — реални и имагинарни, унакрсне густине, унакрсне квадратуре, унакрсне амплитуде и квадратне кохеренције, односно унакрсне корелације) сакупљеног материјала.

Између осталог, закључено је да максимум бројности *B. punctiventris* прати максимум Сунчеве активности (познате као проток на 2800 MHc), са закашњењем од седам година. Дат је и преглед сличних резултата, које су добили истраживачи у другим земљама.

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LD-P AND LT-P LINES OF INSECTICIDES FOR *BOTHYNODERES PUNCTIVENTRIS* GERM. AT DIFFERENT AIR TEMPERATURES*

ABSTRACT: The effects of insecticides monocrotophos, cypermethrin and their ready-made mixtures applied against sugar beet root *weevil* (*B. punctiventris* Germ.) adults at different temperatures were studied.

The experiments were conducted in laboratory conditions at three different temperatures: 14, 20 and 25°C. In 1996 and 1997, the adults used in experiments were collected in Bačka Topola fields with sugar beet as previous crop. The adults were exposed to insecticides by method of insecticide soaked blotting paper and fed with sugar beet cotyledons. The mortality of adults, depending on product was observed every half an hour, starting from 0.5 up to 28 hrs of exposition. Applying probit analyses, ld-p and lt-p lines were constructed, which reflected the changes of toxity depending on insecticides and temperatures. According to position and slope (b) of ld-p lines in 1996, higher toxity of cypermethrin than of monocrotophos was found. The response was more homogeneous to cypermethrin than to monocrotophos. Ld-p lines for mixture run closer to ld-p line for cypermethrin independent of temperature. In 1997, at 14°C and 25°C, higher toxity of cypermethrin than of monocrotophos was observed, the effect of mixture was additive. No mortality was induced with monocrotophos at 20°C. The reason could be in sugar beet root *weevil* population sensitivity decrease to monocrotophos in 1997, or the insects derived from two different populations exposed to different selection pressure (species, volume and exposition length to insecticides). Based on lt-p lines in both experimental years, it could be concluded that cypermethrin, independent of temperature had higher initial toxity than monocrotophos, the mixture achieved additive effect, except in 1996 at 20°C, where the effect was synergised compared to single component effects.

KEY WORDS: sugar beet root weevil, insecticides, temperature, ld-p, lt-p lines

INTRODUCTION

Repeated and frequent use of insecticides, especially compounds of the same or similar mechanisms of action, as in our case, with the application of

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organo-phosphorous compound in suppressing sugar beet root *weevil* could induce the decrease in pest sensitivity to insecticides. To delay this process, the use of binary mixtures (monocrotophos, fenitrothion, chlorpyrifos with cypermethrin, mixture of carbosulfan and cyhalothrine, or fenitrothion and fenvalerate) is recommended. These mixtures have high initial toxity and satisfactory extended activity (R a d i n, 1987, K l o k o č a r - Š m i t, 1987, I n đ i ć et al., 1992, 1995, S e k u l i ć et al., 1997).

The history of use and the degree of selection pressure could be basic orientation in detecting the possible changes in insects' sensitivity and insecticides toxities.

The references on temperature influence on toxity decrease are known (G r a f i u s, 1986, V u k o v i ć, 2003, V u k o v i ć et al., 2004).

The purpose was to define ld-p and lt-p lines for long time used monocrotophos, as the decrease of population sensitivity had already been registered. Also, the possible increase in toxity with addition of cypermethrin at different temperature conditions was expected.

MATERIALS AND METHODS

Experiments in 1996 and 1997 were conducted in laboratory conditions with adults of sugar beet root *weevil* (*B. punctiventris*) collected from Bačka Topola. Toxicological studies for determining the temperature influence (14, 20 and 25°C) on insecticide activities was undertaken by soaking the blotting paper with insecticides and adding treated food (V u k o v i ć, 2003). Before the beginning of the test, the insects were kept for four days in laboratory conditions without any food, at the temperature of 5—9°C. A few hours before the experiment, adults were kept at 20°C to recover their total motion.

Untreated seed of sugar beet NS-Hy-3R was seeded into sterile soil. Plants of sugar beet, at the first pair of true leaves stage are most attractive for sugar beet root *weevil* feeding. Plants were grown without any insecticides. Five young plants were used per repetition. The insecticides used are shown in Table 1.

Table 1. Experimental insecticides for sugar beet weevil (*B. punctiventris*) in controlled conditions (1996. and 1997)

Active ingredient	Product	Concentracion of product (%) (rate a.i., w/v, mg/l)
monocrotophos	Monokrotofos 20 WSC	0,4; 0,2; 0,1% (0,08; 0,04; 0,02)
cypermethrin	Agrometrin 20-EC	0,05; 0,025; 0,012% (0,01; 0,005; 0,0025)
monocrotophos + cypermethrin	Cimogal	0,1; 0,05; 0,025% (0,02; 0,01; 0,005)

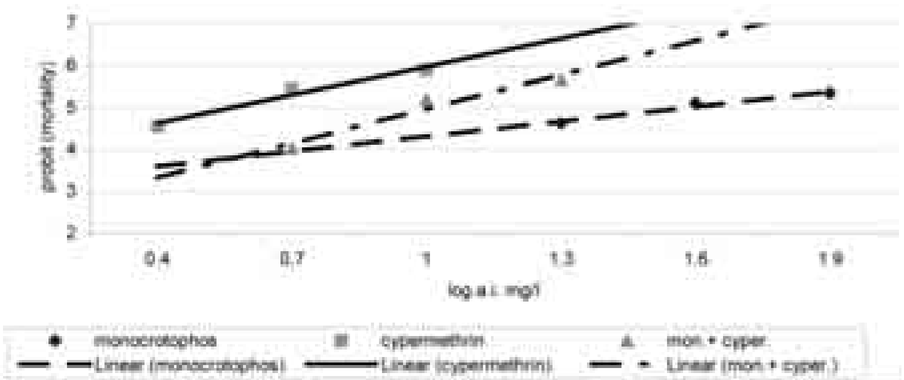
Criterion for mortality was the sum of dead (without any sign of life) + paralysed (which were not able to move when put in normal position) adults.

The mortality of adults was observed from 0.5 to 28 hrs of exposition. The mortality values were corrected for mortality in the untreated control (S c h n e i - d e r, O r e l l i, 1947). Applying probit analyses (F i n e y, 1971) ld-p and lt-p lines were constructed for monocrotophos, cypermethrin and their ready-made mixtures depending on temperatures and season (1996/97).

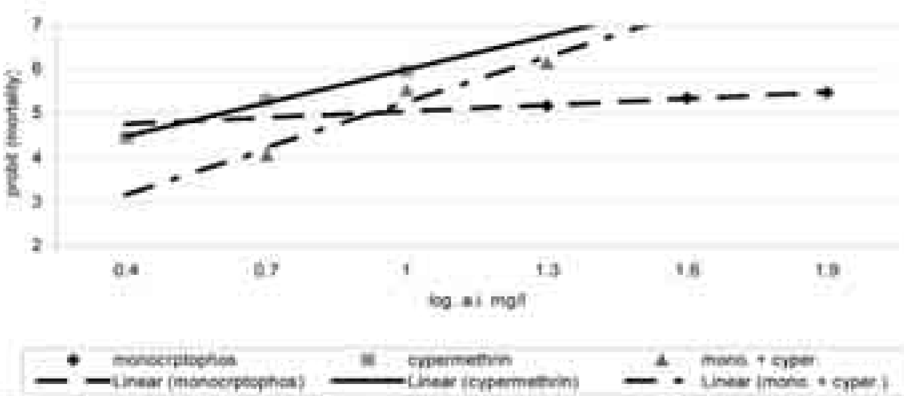
RESULTS AND DISCUSSION

In figures 1—6, ld-p lines for monocrotophos, cypermethrin and mixture, depending on temperatures and population from 1996 and 1997 are shown.

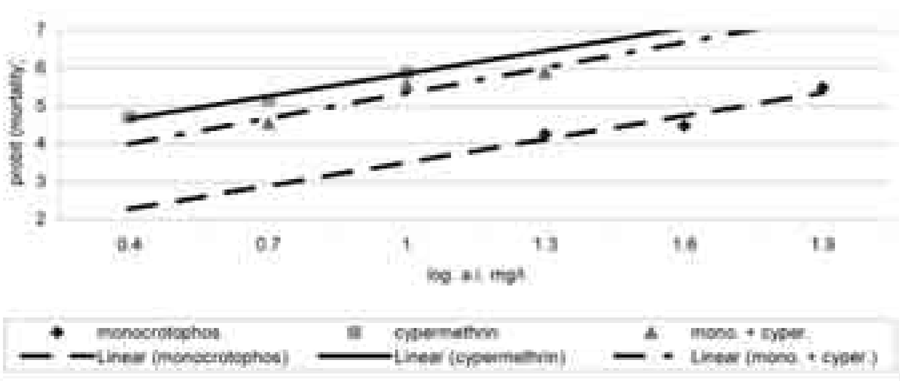
Graph. 1. Ld-p lines monocrotophos, cypermethrin and their mixture for sugar beet weevil adults at air temperature 14°C (1996)



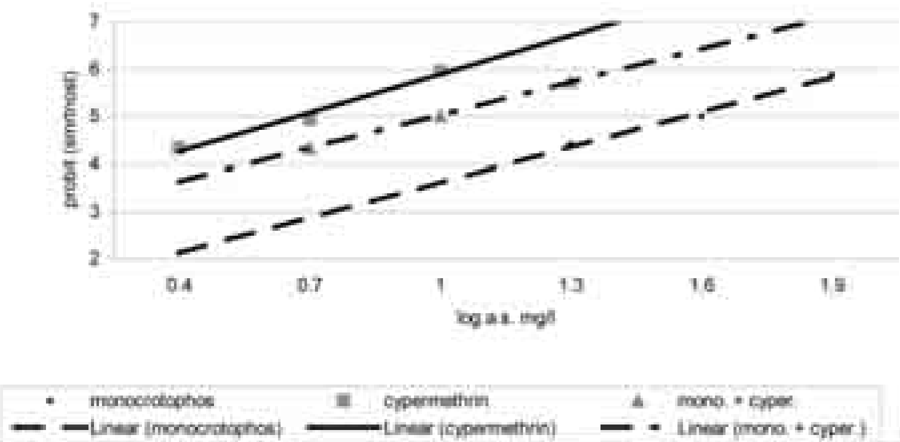
Graf. 2. Ld-p lines monocrotophos, cypermethrin and their mixture for sugar beet weevil adults at air temperature 20 °C (1996 god.)



Graf. 3. Ld-p lines monocrotophos, cipermethrin and their mixture for sugar beet weevil adults at air temperature 25 °C (1996 god.)

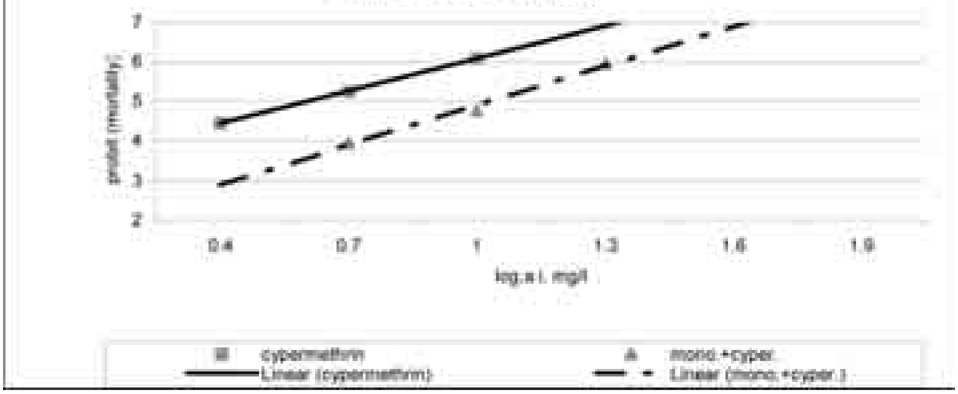


Graf. 4. Ld-p lines monocrotophos, cypermethrin and their mixture for sugar beet weevil adults at air temperature 14 °C (1997 god.)

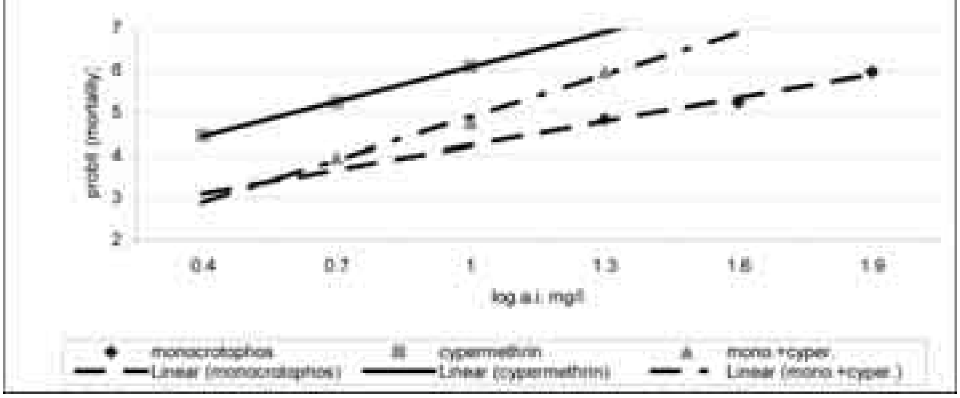


According to the position and slope of ld-p lines in 1996 (graphs 1—3), higher toxity of cypermethrin than monocrotophos, one and more homogeneous responses concerning sensitivity to cypermethrin than to monocrotophos was found. Also, ld-p lines for mixture were more closed than ld-p lines for cypermethrin independent of temperature. The effect of mixture could be judged as active compared to components. Ld-p lines for monocrotophos at 20°C have shown heterogeneous response of sugar beet root *weevil* adults, compared to sensitivity to monocrotophos, compared to ld-p lines at 14°C and 25°C. The position of ld-p lines for monocrotophos at 20°C, almost did not indicate dependence on insecticides concentration, or it was too small.

Graf. 5. Ld-p lines cypermethrin and their mixture for sugar beet weevil adults at air temperature 20 °C (1997 god.)

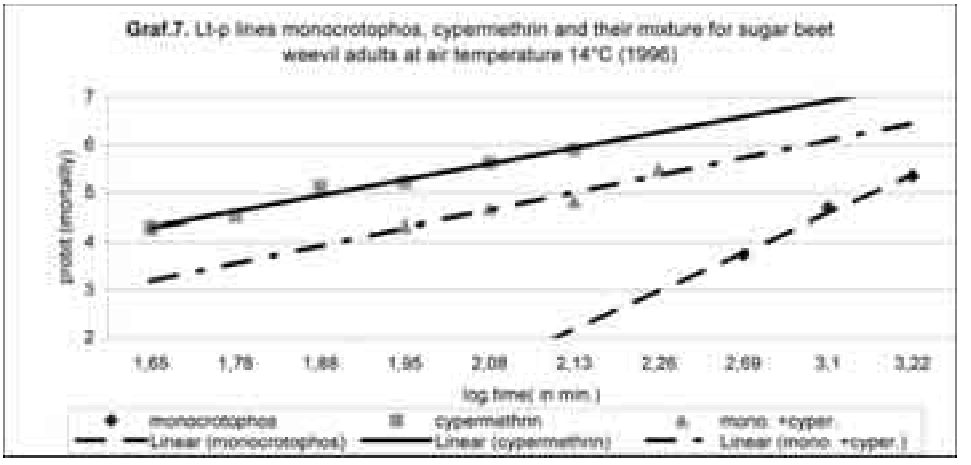


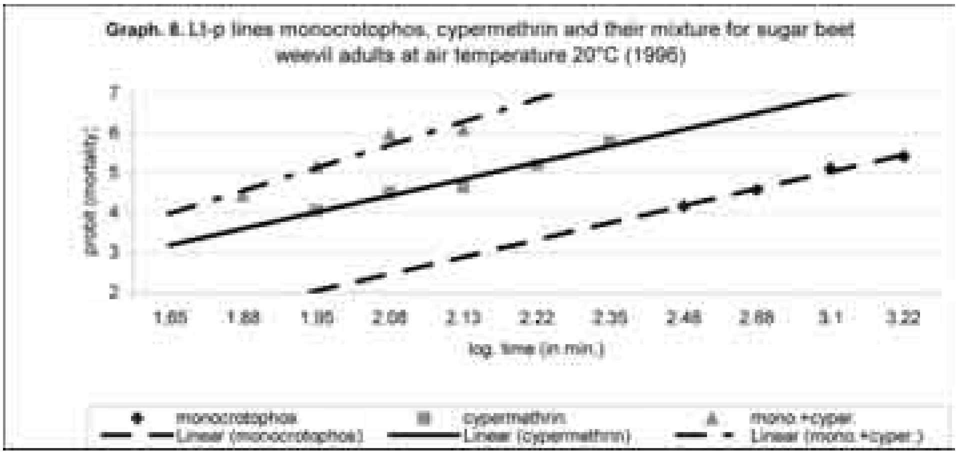
Graf. 6. Ld-p lines monocrotophos, cypermetrin and their mixture for sugar beet weevil adults at air temperature 25 °C (1997 god.)



Assessment of temperature influence on insecticides toxicity to same population in 1997, is presented at Fig. 4—6. At 14°C and 25°C cypermethrin was more toxic then monocrotophos, the effect of mixture was additive. There was no mortality induced by monocrotophos at concentration used at 20°C, and lg-p lines could not be drawn. This results could be explained by decrease of sugar beet root weevil population sensitivity to monocrotophos in comparison to those in 1996, or it could be supposed that two population previously exposed to different selection pressures were present at the same site, or the population was insensitive to mentioned insecticide.

Lt-p lines for monocrotophos, cypremethrin and mixture, depending on temperature and population (1996 and 1997) are shown in Figures 7—12. In 1996 (Figures 7—9), based on lt-p lines position, cypermethrin expressed higher initial toxity than monocrotophos. The position of mixture lt-p lines compared to components, differed depending on temperature conditions. At 14°C, the position of lt-p mixture lines is near to cypermethrin ones. At 20°C, the effect was synergized compared to those of components and at 25°C and was more close to monocrotophos one.



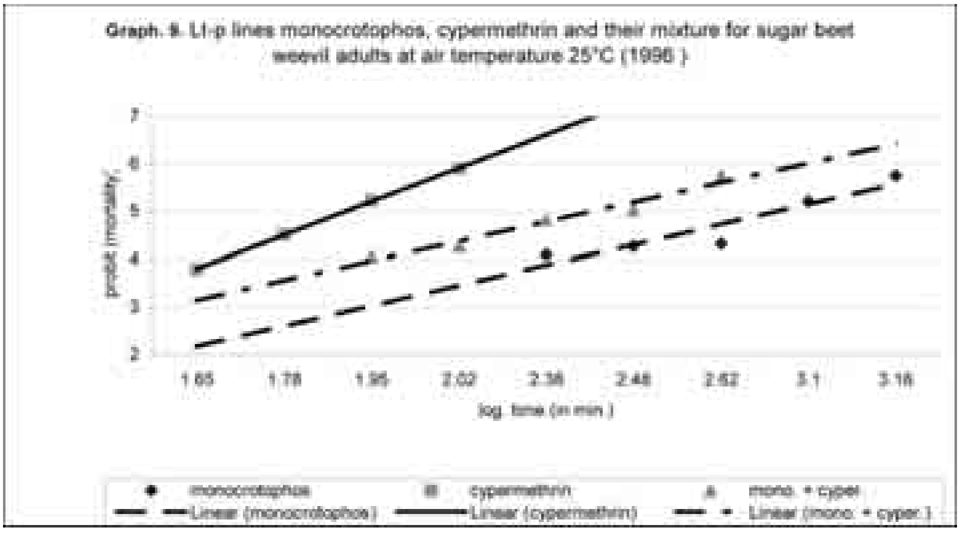


The conclusion based on all of these results would be that at 20°C the velocity of mixture activity compared to single insecticide would be increased.

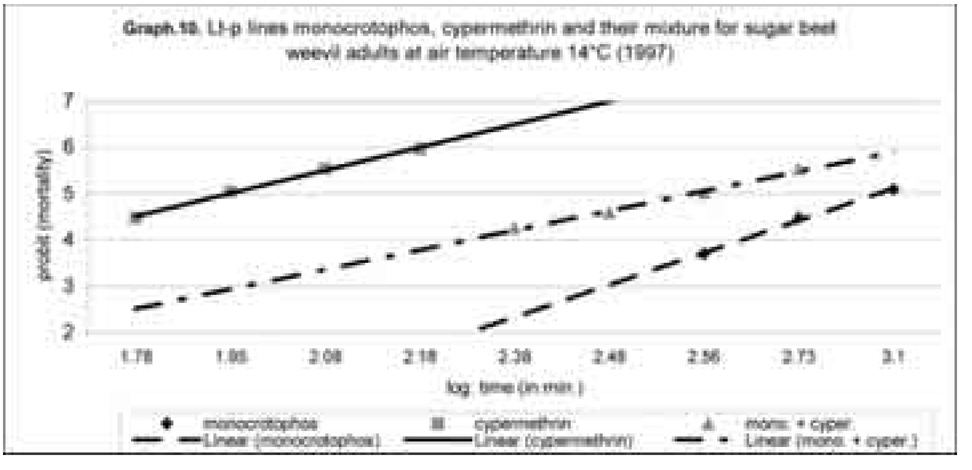
Lt-p lines for monocrotophos, cypermethrin and mixture in 1997 are shown in Figures 10—12. Based on lt-p lines position, cypermethrin has expressed quicker effects than monocrotophos in all cases and the mixture has expressed additive effect at all temperatures.

Comparing lt-p lines from 1996 and 1997, the differences in effects at 20°C indicated that natural populations were heterogeneous, even derived from the same or neighbouring area.

The additive effect of mixture compared to single components effects was expressed at all temperatures in both years.



Graph. 9. Lt-p lines monocrotophos, cypermethrin and their mixture for sugar beet weevil adults at air temperature 25°C (1996)

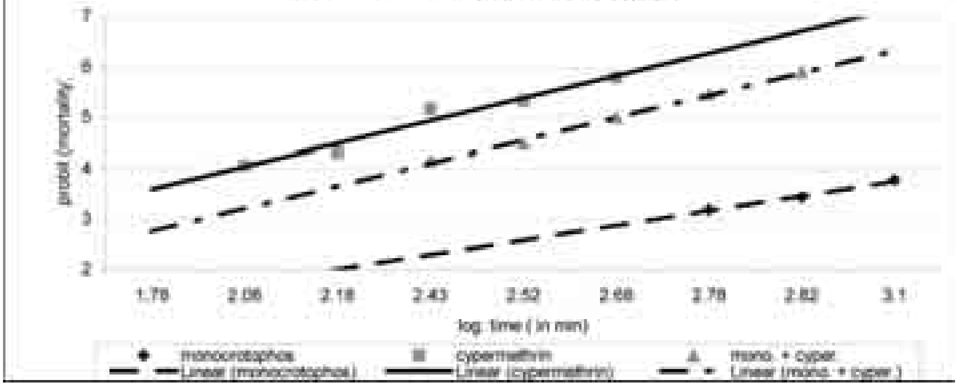


Graph.10. Lt-p lines monocrotophos, cypermethrin and their mixture for sugar beet weevil adults at air temperature 14°C (1997)

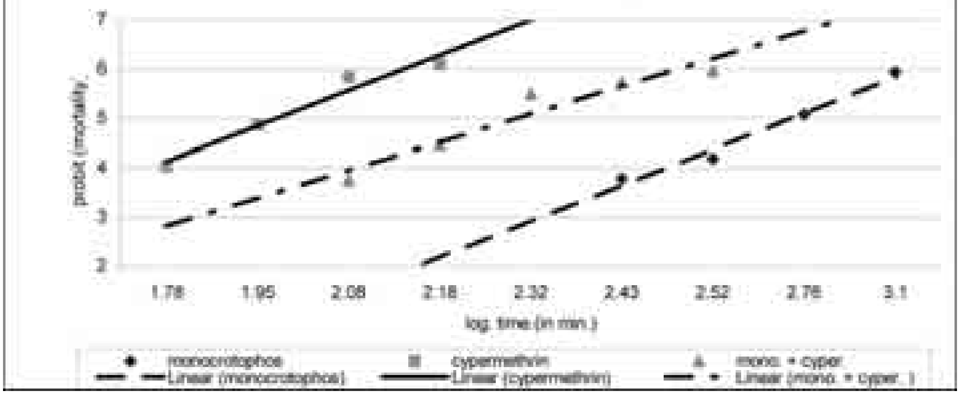
Based on these results, we are positive that the use of mixture (monocrotophos+ cypermethrin) against sugar beet root *weevil* is justified from economical and ecotoxicological reasons.

Low initial toxity of monocrotophos was overcome by adding cypermethrin and this mixture expressed additive effect compared to single components at all temperatures.

Mixture advantages are: additive effect, decreased rate of components (monocrotophos 1,8—2,64 times and cypermethrin 3,6—3,8 times) in respect to single components. Monocrotophos is used at the rate of 1,2—2,5 lit/ha (240—500 a.s./ha), cypermethrin at 0,2—0,3 lit/ha (40—60 g a.s./ha) and mixture at 0,7—1,0 l/ha (133—190 g a.s./ha monocrotophos + 11,1—15,8 g a.s./ha cypermethrin).



Graf. 11. Lt-p lines monocrotophos, cypermethrin and their mixture for sugar beet weevil adults at air temperature 20°C (1997)



Graph.12. Lt-p lines monocrotophos, cypermethrin and their mixture for sugar beet weevil adults at air temperature 25°C (1997)

Previous research has shown changes in reaction of sugar beet root *weevil* from Rimski Šančevi population reaction, slowing it down 3,2 times for monocrotophos in comparison to the population from Bačka Topola (I n đ i ć et al., 1997).

Velocity of insecticide activities on sugar beet root *weevil* adults from Subotica, expressed in medium lethal time (LT_{50}) were: for cypermethrin 2h, for carbosulfan 4h, metidathion 8h and for monocrotophos 17h, indicating 8 times faster activity of cypermethrin than monocrotophos (I n đ i ć et al., 1997).

The recognition of speed activity is very relevant, especially when plant sugar beet is in young growth stage and pest population density is high.

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LD-P И LT-P ЛИНИЈЕ ИНСЕКТИЦИДА ЗА *BOTHYNODERES PUNCTIVENTRIS* G E R M. ПРИ РАЗЛИЧИТИМ ТЕМПЕРАТУРАМА ВАЗДУХА

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Резиме

У раду су приказане ld-p и lt-p линије инсектицида на бази монокротофоса, циперметрина и њихове мешавине (формулисана као готов препарат) за имага репине пипе (*B. punctiventris* G e r m.) на различитим температурама. Огледи су изведени у лабораторијским условима на температурама 14, 20 и 25°C. Као тест инсект послужила су имага репине пипе из локалитета Бачка Топола, прикупљена из производних услова са старих репишта током пролећа 1996. и 1997. године. Токсиколошка испитивања су изведена методом третиране филтер хартије уз додатак третиране хране (биљке шећерне репе у фази котиледона). Смртност имага, зависно од препарата, оцењивана је од 0,5 до 28 h после третирања. Пробит анализом конструисане су ld-p и lt-p линије, показатељи промена токсичности инсектицида зависно од температурних услова. Према положају и нагибу (б) ld-p линија у 1996. години, евидентирана је виша токсичност циперметрина од монокротофоса и већа хомогеност у осетљивости према циперметрину него према монокротофосу. Ld-p линије за смешу ближе су ld-p линији за циперметрин независно од температуре. У 1997. години запажа се на температурама 14 и 25°C виша токсичност циперметрина од монокротофоса, адитиван ефекат смеше, непостојање ld-p линија за монокротофос на 20°C. То упућује на смањење осетљивости популације репине пипе према монокротофосу у 1997. години или је реч о различитим популацијама инсеката, које су биле изложене различитом селекционом притиску (врста, количина и дужина примене инсектицида).

На основу lt-p линија у обе године испитивања може се закључити да је циперметрин независно од температуре, испољио брже деловање од монокротофоса, док је смеша испољила адитиван ефекат, осим у 1996. години на температури од 20°C, када је ефекат синергизован у односу на компоненте.

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JOINT INFLUENCE OF METEOROLOGICAL EVENTS ON LIGHT TRAPPING OF TURNIP MOTH (*SCOTIA SEGETUM* SCHIFF.)*

ABSTRACT: The light-trap collecting results, showing its flight activity, of turnip moth (*Scotia segetum* Schiff.) was examined connected with meteorological events. These factors were instability line, the convergence zone, the cyclogenesis, the country-wide rain, the cold- and warm weather fronts, the maritime- and continental moderate, arctic and subtropical air masses used the data published in "Calendar of Weather Phenomena" between 1967 and 1990 by National Meteorological Service. There were 29832 moths caught during 3232 night by 64 light-trap stations in the examined period. During one night more light-traps operated, therefore 25.021 observing data were worked up. We mean that the observing data are the same as the catching data at one night, at one observing station. The data of meteorological events were collected into groups according to their occurrence on one day alone or together with other ones. They were collected into separated groups according to arriving after a day without any meteorological events or if there were any of them on the previous day. The values of relative catch (RC) were calculated daily for each observing stations and generations used the catching data. There was made a comparison between the relative catch (RC) values and the meteorological events belonging to the data and on previous and following days. Then the relative catch values were summarized and averaged daily. The differences of daily average values of significance levels were controlled with t-test in all the groups. More than 95% significance levels were found in 36 groups. The favourable and infavourable influences of each event are the strongest at that time, when have influence not only alone but also with other effects simultaneously or they follow one another in a short time. Our results prove clearly, it is not enough to examine exclusively the modifying influence of each meteorological event on light-trap collecting. The success of light trapping is modified depending on several combinations of each meteorological event and they are not very often the same as the catching result of event to have an influence only.

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KEY WORDS: light-trap, turnip moth (*Scotta segetum* S c h i f f.), instability line, convergence zone, cyclogenesis, raining, weather front, air mass

INTRODUCTION AND SURVEY OF LITERATURE

The light-trap collected results show the mass ratio of each species with deformation because of the influence of environmental factors. If we want to use these collected data for plant protection purposes, we have to know which factors increase or decrease the number of caught individuals and the degree of these influences.

The cosmic factors such as the solar activity, moonlight, geomagnetism, interplanetary magnetic field sector boundaries, gravitational potential generated by heavenly bodies etc. can influence large territories simultaneously, so these influences are the same in the whole country in a moment. They are also favourable in the examinations of the phases of moon changes in a periodic way, so good prognosis can easily be made for their modifying influence. The solar activity and the caused effects of other cosmic factors also take place periodically, although, in order to make forecast for determined dates cannot be done.

It is the largest problem, during the examination of collecting data, to determine the influence of weather, always changing in time and space.

In one of our former studies (N o w i n s z k y et al., 1994) we were making use of the fortunate circumstances that a principal weather observation station is located in Szombathely where a light-trap observation site was in operation from 1962 to 1970. We examined the formation of the light-trap catch in connection with the weather elements that are only regularly measured at principal weather stations (vapour pressure, saturation deficit and wind direction, increasing or decreasing cloudiness, cloud height, fog, thunder and lightning that precede storms).

Sorry to say that new pieces of information can hardly be used by plant protection prognostic. The weather elements, although their modifying influences are well known, influence the current catch with all the other factors simultaneously and in reciprocal effect with them. It is also a problem that most of the light-trap stations are far from the meteorological observation stations and even the most important weather elements, surrounding the light-trap stations are not measured. It is very difficult to examine the connection between weather and light-trap catch using the data of national light-trap network. That is why we began to study the influences of the upper-air phenomena, weather events and the macrosynoptic weather types. The territory of Hungary is only 93 000 km^2, therefore the macrosynoptic weather types and air masses can be the same in the whole country, the weather fronts can pass through the territory of Hungary during one night.

The insect phenomenon of life exerting influence of meteorological events is examined generally with the atmospherical process. It is clear that the joint influence of meteorological events has more importance according to the living creature, but publications dealing with these researches are less known. We could not find fundamental publications connected with this theme in foreign literature. The modifying influence of collecting, connected with 22 kinds of air masses and 20 kinds of weather fronts and discontinuity levels determined after Berkes (1961) were examined in our publication (Puskás et al., 1997).

The air masses, the weather fronts and the discontinuity levels were determined for the area surrounding Budapest and we regret to say that they are not valid for the whole territory of Hungary (Csizsinszky, 1964). We spread our examinations of the joint influence of meteorological events (weather fronts, air masses, instability line, convergence zone, cyclogenesis and countrywide rain). These pieces of information are part of regular meteorological data and they are simultaneously valid for the whole country or they pass the territory of Hungary at one night.

MATERIAL

The "Calendar of Weather Phenomena" published monthly by National Meteorological Service contains cold and warm weather fronts and 6 kinds of air masses: arctic continental (Ac), arctic maritime (Am), moderate continental (Mc), moderate maritime (Mm), subtropical continental (Tc) and subtropical maritime (Tm) ones.

By air masses, we mean the wide-spread mass of air, although physical characteristics (mainly the temperature and degree of humidity) continuously change horizontally, but their changes are very small and their vertical dispersions are almost the same.

The instability lines, the convergence zones, the point of time and the length of time belonging to cyclogenesis and the countrywide rain are found in the above-mentioned "Calendar of Weather Phenomena". The instability line (squall line) is a convective activity, which moves in a band or line. The short-term intense strengthening of wind speed is the characteristic of its passing and then come violent tempest and thunderstorm. The convergence develops if two atmospheric motions come from two different directions in the atmosphere. Generally, this process takes place along long line, the air accumulates here and one part of it rises up high. It comes often with weather fronts and cyclons. Cyclogenesis is the development or strengthening of cyclonic circulation.

The catching results of turnip moth (*Scotia segetum* Schiff.) were worked up connected with these meteorological events. We used the data of light-trap network in Hungary, uniformly the Jermy type light-traps. The light source is a 100 W normal light bulb at 2 meters above the ground, colour temperature: 2900 K°, the killing material is chloroform. The traps of the plant protection worked from 1st April to 31st October while the forestry ones all the year round, independently of the time of sunrise and sunset, every night from 6 p.m. to 4 a.m. All time data are given in universal time (UT). The insects trapped during one night were stored in one bottle, so the whole catch of one night at one observational site is interpreted as one observational datum.

The collected data of turnip moth (*Scotia segetum* S c h i f f.) were used for examinations received from 64 observing stations of national agricultural and forestry network operated between 1967 and 1990. During 3 232 nights, 29 832 individuals were caught by the traps. We used 25 021 observing data in our examination. By observing, we mean the catching data at one night at one observing station, independently of the caught moth number.

METHODS

The number of individuals trapped at different observation sites and times cannot be compared to each other even in the case of identical species, as each trap works in different environmental factors and they constantly vary according to time as well. To solve the problem, we calculated relative catch (RC) values for observation sites, species and generations from the catch data. RC is the quotient of the number of individuals caught during the sampling interval (1 night) and the mean values of the number of individuals of one generation counted for the sample interval. In this way, in the case of expected mean number of individuals, the value of relative catch is 1.

The data of meteorological events were collected into groups according to their occurrence on just one day or together with other ones. They were collected into separate groups according to arrival after a day without any meteorological events or if there were any on the previous day. We made a comparison between the relative catch calculated from the collected results and the meteorological events the previous and following 2-2 days. Then, the relative catch values were summarized and averaged daily. The differences of daily average values of significance levels were controlled with t-test in all the groups.

RESULTS

The light trapping success of turnip moth (*Scotia segetum* S c h i f f.) connected with meteorological events is shown in Table 1. The significance level was more than 95% in relative catch values in 36 groups.

DISCUSSION

The instability line decreases alone the number of caught specimen only in the case when it repeats during some days. If cold weather front comes after it the same day, the unfavourable influence can be shown. If it comes with other meteorological events, the influence is unfavourable or ineffective for catching result. On the following day, the quantity of collecting increases only if subtropical air mass also arrives. The convergence zone is ineffective alone but if it comes together with cyclogenesis the number of collected moths decreases on the previous day. There is unfavourable influence if it comes with moderate maritime air mass from the previous day until following day.

The collected results are low on previous day if only cyclogenesis can be found. On the day of arrival, it is also low when it comes with any other meteorological event. If it comes with countrywide rain, the catching is low even on the following day. It is remarkable that the countrywide rain alone is favourable before and after the event for the success of catching but if it comes with any other meteorological event the catching is unfavourable for it. The cold weather front arriving alone is favourable on previous days for collecting, but it is unfavourable on the day of arrival and the following one. It is also unfavourable if it arrives together with moderate air mass and coming with arctic air mass increases collecting but it decreases it on the next day. The warm weather front arriving with subtropical air mass is favourable for catching on previous day and on the day of arrival, but it is unfavourable if warm front comes with moderate maritime air mass. The number of caught moths is low on the day of arrival and on the following one at coming of moderate maritime air mass and it is independent of the combination with any other meteorological event. The catching is not very high, except if it comes with other meteorological event, on previous day of arrival of the moderate continental air mass but it is high on the following days. If the instability line on previous day is followed by moderate continental air mass with cold front on the day of arrival, the catching of previous night is high but it is low on the following one. If the instability line on previous day is followed by moderate maritime air mass with cold front on the day of arrival, the low collecting can be observed on that day but will change upwards on the following one. The subtropical maritime air masses, arriving alone, with instability line and cold front are unfavourable but they are favourable on the previous and the following days. If these kinds of air masses come with convergence, zone and cyclogenesis the collecting is small on the previous night. The subtropical maritime air masses, arriving with warm weather front are favourable for success of collecting on the previous day and on the day of arrival.

Table 1. Relative catches of turnip moth (*Scotia segetum* S c h i f f.) connected with meteorological events using the data of light-trap network in Hungary operated between 1967 and 1990

Name of event			Values of relative catches at the days around events					
N	–1	On the day of event	–2	–1	0	→0	1	2
1.	∅	Inst.	1.17 (232)	1.01 (254)	1.17 (317)	0.55 (39)	0.95 (143)	1.01 (110)
2.	∅	C	1.04 (236)	0.98 (297)	1.05 (391)	1.06 (457)	1.16 (284)	1.02 (189)
3.	∅	C	1.00 (142)	0.86 (166)	0.99 (395)	0.86 (222)	0.93 (367)	0.93 (264)
4.	∅	CF	1.29 (81)	1.36 (81)	0.89 (279)	0.56 (53)	1.07 (243)	1.09 (180)
5.	∅	CR	1.76 (52)	1.78 (72)	1.22 (76)	1.04 (28)	1.13 (58)	1.47 (56)
6.	∅	Mc	1.05 (91)	0.66 (90)	1.34 (90)		1.32 (47)	1.51 (44)

7.	∅	Mm	0.61 (20)	0.50 (16)	0.64 (96)		1.31 (82)	0.76 (71)
8.	∅	Sc	0.64 (79)	1.03 (87)	0.95 (108)		0.50 (39)	0.56 (31)
9.	∅	Sm	1.54 (55)	1.36 (68)	0.97 (99)	0.80 (59)	1.24 (47)	1.32 (47)
10.	∅	Inst. Sm	1.11 (148)	1.02 (155)	0.97 (155)		0.96 (43)	0.87 (34)
11.	∅	Inst. Mm	1.05 (74)	1.22 (79)	0.94 (96)	1.10 (28)	1.17 (17)	1.42 (16)
12.	∅	Inst. CF Sm	1.11 (25)	1.53 (25)	0.86 (27)		1.57 (30)	1.35 (27)
13.	∅	Inst. CF Mm	1.02 (209)	1.03 (368)	0.96 (304)		0.92 (306)	1.14 (252)
14.	∅	Inst. CF Sm Am	1.12 (29)	0.77 (29)	0.97 (28)		1.78 (29)	1.24 (27)
15.	∅	Inst. CF Mm Sm	1.23 (22)	1.51 (51)	1.03 (50)		0.74 (36)	1.19 (34)
16.	∅	Inst. CF Mm CR	1.06 (30)	0.78 (32)	0.73 (35)		0.59 (34)	1.07 (35)
17.	∅	CV C Sm	1.43 (25)	0.85 (28)	1.04 (21)			
18.	∅	CV C Sm CR	1.20 (22)	0.81 (22)	0.94 (21)			
19.	∅	CV Mm	1.46 (35)	0.82 (38)	0.72 (52)		0.44 (29)	0.93 (27)
20.	∅	C CR	1.05 (94)	0.93 (134)	0.91 (202)	0.98 (75)	1.01 (180)	1.35 (94)
21.	∅	C Mm	1.07 (62)	1.04 (69)	0.79 (95)	1.03 (14)	1.03 (103)	1.06 (90)
22.	∅	C Mm CR	1.25 (49)	0.66 (71)	0.62 (104)		0.80 (60)	0.96 (57)
23.	∅	C Am CR	1.06 (25)	0.90 (42)		0.87 (38)	1.49 (41)	
24.	∅	CF Mc	0.75 (218)	1.05 (245)	1.09 (318)		0.97 (266)	0.76 (199)
25.	∅	CF Mm	1.02 (993)	1.03 (1201)	0.92 (1630)	0.88 (156)	0.94 (1463)	0.94 (1392)
26.	∅	CF Mm CR	1.02 (34)	1.07 (56)	0.75 (72)	0.71 (21)	0.83 (73)	0.66 (58)
27.	∅	CF Ac	0.98 (45)	1.21 (59)	1.16 (73)		0.46 (63)	0.99 (36)
28.	∅	CF Am	0.94 (156)	1.01 (208)	1.22 (228)		0.92 (203)	0.98 (173)
29.	∅	CF Am CR	0.97 (46)	0.70 (48)		0.90 (23)		
30.	∅	WF Sm	1.38 (50)	1.54 (60)	1.66 (73)		1.18 (16)	
31.	∅	WFMm	0.96 (33)	0.81 (50)	0.48 (68)		0.96 (39)	1.35 (30)

32.	∅	WF Mc	0.91 (22)	0.42 (45)	1.27 (45)			
33.	Inst.	CF Mc	1.11 (58)	1.15 (60)	1.12 (62)		0.95 (60)	0.97 (33)
34.	Inst.	CF Mm	0.99 (54)	1.00 (69)	0.42 (68)		1.00 (51)	1.30 (46)
35.	Inst.	CF Mm CR	1.11 (44)	0.83 (39)	0.53 (36)		1.19 (25)	
36.	CV	CF Mm	0.92 (45)	1.02 (49)	1.48 (54)		1.08 (33)	1.05 (20)

Notes: –2 and –1 = previous days of event, 0 = the day of meteorological event, →0 = following days with the same event, 1 and 2 = first and second days following the event, ∅ = a day without meteorological event, Inst. = instability line, CV = convergence zone, C = cyclogenesis, CR = country-wide rain, CF = cold weather fronts, WF = warm weather fronts, Mm = moderate maritime air mass, Mc = moderate continental air mass, Am = arctic maritime air mass, Ac = arctic continental air mass, Sm = subtropical maritime air mass, Sc = subtropical continental air mass. If the significant difference of value of relative catch is more than 95% level on two following days it is shown with italic numbers. If the value of relative catch differs more than 95% significance level from the relative catch average of summarized all the other data, it is shown with bold numbers. The number of observing data is given in parentheses. The meteorological events are not given in the table when there are less than 20 observing data and probably this is the reason they do not have significant differences neither to the previous day catching nor the average of summarized all the other data.

The number of caught moths shows decrease on the arrival day of subtropical continental air mass and it is the same on the next day. The number of collected moths is lower on arrival and on the following days of subtropical continental air masses. The catching is high on the previous and on the arrival days belonging to the arctic air mass coming with cold weather front, but there is a decrease on the following day.

Our results prove clearly: it is not enough only to examine the modifying influence of each meteorological event on light-trap collecting. The success of light trapping is modified depending on several combinations of each meteorological event and very often they are not the same as the catching result of event to have an influence alone.

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УТИЦАЈ МЕТЕОРОЛОШКИХ УСЛОВА НА ХВАТАЊЕ ПОДГРИЗАЈУЋЕ СОВИЦЕ (*SCOTIA SEGETUM* SCHIFF.) СВЕТЛОСНИМ КЛОПКАМА

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Резиме

Резултати прикупљања светлосних клопки које показују летачку активност подгризајуће совице (*Scotia segetum* Schiff.) испитани су заједно са метеоролошким условима. Ови фактори били су линија нестабилности, зоне конвергенције, циклогенеза, падавине широм земље, хладни и топли временски фронтови, приморске и континенталне умерене, арктичке и суптропске ваздушне масе применом података из „Календара временских феномена” који је између 1967. и 1990. год. објавила Национална метеоролошка служба. У испитиваном периоду у 64 станице са светлосним клопкама током 3232 ноћи ухваћено је 29.832 совица. Током једне ноћи радило је више светлосних клопки те су тако добијени подаци са 25 021 посматрања. Сматрали смо да су подаци посматрања исти као подаци о ухваћеним инсектима током једне ноћи, у једној посматрачкој станици. Подаци о метеоролошким условима сврстани су у групе у складу са њиховом појавом током само једног дана или заједно са другима. Сврстани су у одвојене групе у складу са доласком након дана без било каквих метеоролошких промена или уколико их је било претходног дана. Вредности релативног улова (РУ) обрачунаване су дневно за сваку од посматрачких станица и генерација коришћењем података о хватању. Урађено је поређење између вредности релативног улова (РУ) и метеоролошких услова тог, као и претходних и следећих дана. Тада су релативне вредности резимиране, а просечне вредности обрачунаване дневно. Разлике дневних просечних вредности нивоа значаја контролисани су у свим групама т-тестом. У 36 група нађено је више од 95% нивоа значаја. Погодни и непогодни утицаји сваког догађаја су најјачи у то време, када имају утицај не само сами него истовремено и са другим ефектима или следе један други у кратком времену. Наши резултати јасно доказују да није довољно испитати искључиво промењиви утицај сваког метеоролошког догађаја на хватање светлосним клопкама. Успех хватања клопкама се мења у зависности од неколико комбинација сваке метеоролошке промене и често није исти као када утицај има само резултат улова.

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COMPOSITION OF COCCINELLID COMMUNITIES IN SUGAR BEET FIELDS IN VOJVODINA*

ABSTRACT: This paper presents a synthesis of the results obtained during a long-term investigations conducted on the distribution of aphidophagous coccinellid species and their quantitative and qualitative structure in sugar beet fields in Vojvodina. Composition of coccinellid communities and the annual changes in abundance of species are influenced by many variable environmental factors, but also by the prey availability during the season. Chemical treatments against *flea beetles* in May or/and against noctuid larvae in late July and the type of the adjacent crops may also affect the quantitative composition of adults coccinellid on sugar beet fields. During the season, adults coccinellid are more abundant than larvae. The qualitative structure of coccinellid communities in sugar beet fields is not different than those from other field crops. These communities consist mainly of *Coccinella septempunctata* L.; *Semiadalia undecimnotata* Schn.; *Propylaea quatuordecimpunctata* L.; *Hippodamia (Adonia) variegata* Goeze and *Hippodamia tredecimpunctata* L. Other species are present in a small fractions.

KEY WORDS: Coccinellid communities, composition, aphid density, plant density

INTRODUCTION

Aphids can be considered a major pest of sugar beet crops in Vojvodina. They appear on the crop with a variable intensities every year. Infestation of the plants by aphids differs within a single field and between fields with different locations. Two aphid species feed on and inflict the most damage on sugar beet in Vojvodina. The green peach aphid, *Myzus persicae* Sulz. which occurs on young plants early in the season and the bean aphid, *Aphis fabae* Scop. which occurs all during the season. The crop is more commonly attacked by the bean aphid than green peach aphid. According to Lowe (1975), sugar beet is relatively poor host plant for *M. persicae* and this aphid normally occurs in small populations which increase relatively slowly. These two aphids

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are important in most sugar beet production areas, because they are a vector of *beet yellow virus*. Although sugar beet is commonly attacked by *Aphis fabae*, some aphid species, which are transient on the crop may be found in small numbers during the summer (Č a m p r a g, 1973).

Aphids on field crops are usually attacked by complex of predators. Most of these predators are polyphagous. However, both of predators and their prey form a system of interrelated components. The majority of principal aphid predators enter the fields from outside. Therefore, knowing the sources from which predators are moving is critical. The nature of surrounding habitat, especially the kind of adjacent crops influence not only which species of predators are going to be present in a cultivated field but also the number of each. Innumerable papers have been published on complexes of aphidophagous species associated with various host plant/aphid system (P r u s z y n s k i and L i p a, 1971, H o d e k, 1973, H o n e k, 1981, 1982, 1983, R a d w a n, 1983, T h a l j i, 1981, 1988; L a z a r e v s k a and T h a l j i, 1997). The aim of this work was to determine the composition of coccinellid communities in sugar beet fields, their abundance, seasonal and annual changes.

MATERIAL AND METHODS

The occurrence and population density of aphids and aphidophagous coccinellids were recorded during long-term investigations every year. The study was carried out at several localities representing the main landscape types in Vojvodina. Depending on weather conditions, sugar beet fields were regularly visited, at two weeks interval, from early May until the late of September each season. At the time of coccinellid settling on the crops (early May), adults coccinellid were visually counted by "walking counts" method (H o n e k, 1982), along a transect of 100 walks (about 80 meters). At this period, when at least five coccinellid adults were recorded, this indicated that the young plants were occupied by alatae or the first small colonies of aphids especially those of *Myzus persicae*. Later on, the ratio of infested plants was estimated by inspecting of 100 plants. Within a five rows, 20 randomly selected plants, per each were carefully inspected and the numbers of egg batches, larvae and adults of coccinellid were also registered.

RESULTS

Sugar beet fields play an important role in the preservation of coccinellid communities and they may be considered as an ecological reservoir for many species of natural enemies. These findings were confirmed in early studies by T h a l j i (1994). The author emphasized that sugar beet fields in Vojvodina, annually harboured about 27% of the overall coccinellid populations. On the other hand, coccinellid communities on sugar beet fields are similar to those on other field crops and there are no coccinellid species found to be closely associated with this crop. A wide spectrum of species occurs on all crops infested by aphids in Vojvodina (Š i m i ć and P a v k o v, 1988, Č a m p r a g et al., 1990, T h a l j i, 1991, 1994).

OCCURRENCE AND SEASONAL VARIATION IN COCCINELLID SPECIES

The occurrence of species and the richness of coccinellid communities varried from year to year and from locality to locality. Seasonal variation in coccinellid numbers was primarily affected by climatic conditions, plant density and the availability of suficient food resources. At the settling time of adults, coccinellid numbers may be affected by the residual effects of earlier treatments with systemic insecticides against the beet weevil or flea beetles. On the other hand, in particular seasons coccinellid populations were also destroyed by spraying against aphids or noctuid larvae. The peak in numbers of active predators on sugar beet crop generally coincided with the peak abundance of their prey. The number of aphid-infested plants in the fields and the aphid populations increased between the mid of May and the late June, or the beginning of July (Č a m p r a g, 1973, Č a m p r a g et al., 1990). Locations of sugar beet fields and the structure of adjacent crops determine the richness and the appearance of species during the season. The most abundant and regularly observed coccinellid species on the crop in all years of investigations were *Coccinella septempunctata* L., *Semiadalia undecimnotata* S c h n., *Hippodamia (Adonia) variegata* G o e z e., *Propylaea quatuordecipunctata* L., *Scymnus rubrumaculatus* G o e z e. and *Hippodamia tredecimpunctata* L. In most seasons, these six coccinellid species represent about 90% of the total number of observed coccinellids on the crops (Figure 1). All coccinellid species, other than those mentioned obove occurred in extremely low numbers. The occurrence of these species which mainly consist of *Adalia bipunctata* L, *Coccinula quatuordecimpustulata* L., *Harmonia quadripunctata* and the mycophagous species *Psyllobora vigintiduopunctata* L. largely depends on the prevailing factors mentioned above. For example, the species *H. variegata* and *H. quadripunctata* were more abundant in dry seasons, especially they influx sugar beet fields after wheat harvesting. The two-spotted lady bird, *A. bipunctata* was frequetly registered in sugar beet fields adjacent to orchards or hop stands. The species *C. 14-pustulata* was recorded in fields adjacent to uncultivated lands or to alfalfa crops. *H. 13-punctata* was frequently observed in fields near channels or within humid places in the fields. In particular years, this species forms small aggregations on the under side of the leaves. The mycophagous species *P. 22-punctata* was usually numerous at the end of the season, especially on plants infected by the *powdery mildew*, *Erysipha betae*, as well as in weedy fields.

In general, observations showed that coccinellid numbers were very low in the earlier stages of aphid colonisations, even in years with high aphid numbers. However, with medium or outbreak numbers of aphids, the numbers of coccinellids increased when aphid numbers were at peak and were the highest when they had fallen.

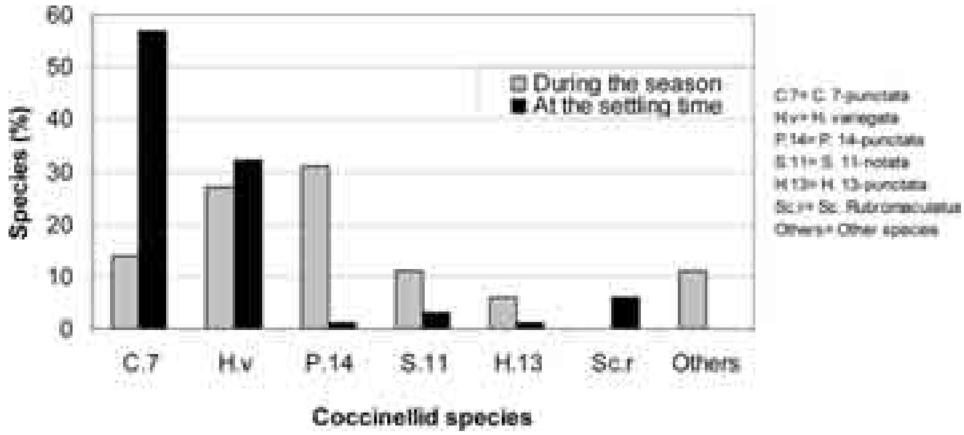

Figure 1. Annual changes in coccinellid communities in sugar beet fields in Vojvodina

Qualitative coccinellids composition was strongly correlated with food availability and plant density. Adults coccinellid spread in sugar beet fields immediately after the settling of aphids. At this time, the sparse stands of young plants with low aphid populations were more convenient for thermophilic species such as *C. Septempunctata, H. variegata* and *S. rubromaculatus*. As the build up of aphids population raise, the quantitative and qualitative composition of coccinellid changes. From the end of May onwards, *S. undecimnotata* and *P. quatruodecimpunctata* were frequently observed and as the stands became denser, the later becomes more dominant on the crop. Our results are in accordance with the results of several authors (I p e r t i, 1965, 1978, H o n e k, 1979, 1982, R a d w a n and L o w e i, 1983)

DEVELOPMENT OF COCCINELLIDS ON SUGARBEET

In the climatic conditions of Vojvodina, sugar beet infestation by aphids varied in intensity from year to year and from locality to locality. Aphid numbers among plants and among leaves within individual plants were highly variable as well. In most cases, young and inner leaves support higher aphid populations.

The spring generation of coccinellids, however, appeared to disperse in early June irrespectively of the numbers of aphids on sugar beet plants, seemingly in search for more suitable egg-laying sites. According to H o n e k, (1980), coccinellid females begin to reproduce after some time spent on feeding on aphid population. The ovarioles do not ripe before the density of aphids increases to certain threshold value, which is greater than that required for settling (H o n e k, 1978). Our observations in sugar beet fields are in accordance with these findings. However, adults coccinellid were more abundant than larvae. Egg batches and larvae of more than one species may be observed on single plants, heavily colonized by aphids. On plants like these, three coccinellid species, *C. Septempunctata, S. undecimnotata and H. variegata* were recorded to pass through their developmental stages. On the other hand, a single larvae of *P. quatuordecimpunctata* may be found wandering within plants in summer until the end of season.

DISCUSSION

The complex of coccinellid species is a dynamic unit whose composition is not stable. Both, the absolute numbers and the relative ratios of the species varied during the vegetation period. However, stands of field crops contain similar coccinellid communities in Vojvodina. In previosly published data (Thalji, 1994). Coccinellid communities were analyzed in aphid infested stands of agricultural crops: lucerne, sugar beet and sunflower. Thirteen coccinellid species were found, eight of them were the most abundant and could be observed in the investigated area every year. In the present study, ten species were observed to appear in sugar beet fields, six of them were regularly registered on the crop every year, while the remainder, occasionally appear depending on the prevailing conditions (geographic position, adjacent crops and agricultural practices).

The composition of coccinellid communities is largely determined by environmental factors. Microclimatic conditions influenced through plant density, prey density, annual changes in abundance of species and differences in rate and timing of migration (Iperti, 1965, 1978, Hodek, 1973, Honek, 1979, 1981, Radwan and Lovei, 1983).

At the settling time of adults coccinellid on sugar beet fields, the number of species present is largely determined by the richness of populations which survived from the previous year. In all years of investigations, the first registered species on sugar beet were *Coccinella septempunctata* and *Hippodamia variegata*. At this period, the young plants are low and the stands have a drier and hotter microclimat, which attracts these two thermophilic species (Iperti, 1965, 1978, Honek, 1979). Our studies indicated that the above mentioned species represent about 90% of the overall coccinellids population in early May.

After some time spent on feeding on aphid population, the coccinellid females begin to reproduce. As revealed previously (Honek, 1978) the ovarioles do not ripe before the density of aphids increases to certain threshold value, which is greater than that required for settling. Prolonged feeding on subthreshold density of aphids does not enable the ovariole ripening. On the other hand, if the prey density falls below certain value, the beetles cannot maintain their own body weight and they leave the field (Frazer et al., 1981). Our results also showed that 3—4 coccinellid species pass through their developmental stages on single beet plants heavily infested by *Aphis fabae* during the season. Later on, quantitative and qualitative structure of species mainly changed depending on the prevailing factors. For example, the abundance of *C. septempunctata* decreases with increasing crop density. Dense beet crops, with moist and dark lower strata and completely shaded ground surface are now more suitable for *P. quatuordecimpunctata* and *H. tredecimpunctata*.

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САСТАВ ЗАЈЕДНИЦЕ БУБАМАРА НА ПОЉИМА ПОД ШЕЋЕРНОМ РЕПОМ У ВОЈВОДИНИ

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Резиме

У овом раду презентовани су резултати вишегодишњих праћења сезонских промена, квантитативни и квалитативни састав афидофагних врста бубамара на пољима шећерне репе у Војводини.

Структура заједнице бубамара, као и годишње промене у саставу врсте, зависи од великог броја променљивих фактора. Најважнији фактори који одређују састав врсте унутар заједнице су климатски услови и присуство адекватне хране. Међутим, треба посебно истаћи утицај микроклиматских услова створених променом склопа биљака током вегетационог периода. Наиме, сувљи микроклимати који владају на пољима шећерне репе на почетку вегетације, пре затварања редова, више одговарају термофилним врстама бубамара. У том периоду врста *Coccinella septempunctata* представља више од једне половине целокупне популације бубамаре на том усеву (57%). Током лета, односно после склапања редова, усеви шећерне репе имају влажније микроклимате, те више одговарају хигрофилним врстама бубамара. Током лета и јесени врста представља више од 30% целокупне популације бубамара. С друге стране, у појединим сезонама, појава бубамара зависи од спроведених хемијских мера против буваћа у мају и/или против совице током јула. На квантитативни састав бубамара на пољима под шећерном репом могу утицати и врсте суседних усева.

Током сезоне одрасли инсекти више су присутни у односу на ларве. Ипак, ларве се могу срести на појединим биљкама које су јако нападнуте биљним вашима. Квалитативни састав заједнице бубамара на шећерној репи не разликује се значајно и сличан је саставу на осталим усевима.

На усевима шећерне репе заједнице бубамара углавном се састоје од врста *Coccinella septempunctata* L., *Semiadalia undecimnotata* S c h., *Propylaea quatuordecimpunctata* L., *Hippodamia (Adonia) variegata* G o e z e. и *Hippodamia tredecimpunctata* L. Поред наведених, могу се срести и друге врсте бубамара али оне представљају само један мали фрагмент целокупне популације током сезоне.