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Compounds of essential oils as markers of hop resistance (*Humulus lupulus*) to powdery mildew (*Podosphaera macularis*)

Andreja CERENAK[1], Dragica KRALJ[2], Branka JAVORNIK[3]

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ABSTRACT

Field assessments of resistance to powdery mildew of 103 hop cultivars, analyses of hop essential oil and correlation between the score for powdery mildew and the relative percentage of essential oil compounds were performed over three years. Seven susceptibility markers (peaks 29 (methyl-5-methyl-hexanoate), 30 (myrcene), 34 (iso-amyl-iso-butyrate), 38 (1-8-cineole), 56 (methyl-octanoate), 88 (methyl decanoate) and 122 (undetermined peak)) and seven resistance markers (peaks 112 (santalene), 114 (germacrene-D), 118 (alpha-selinene), 138 (cariophylene epoxide), 26, 135 and 158 (undetermined peaks)) were selected from peaks with a positive or negative correlation between powdery mildew scores and their presence in the essential oil of extremely susceptible or resistance cultivars. The number and value of resistance/susceptibility markers decreased with an increase in the level of cultivar susceptibility/resistance. Susceptible cultivars mainly appeared to contain North American germplasm, while more resistant cultivars belong to European hops. Analysis of the presence/absence of the selected markers showed that the absence of susceptibility markers, particularly 30, 34 and 38, can be of practical value in resistance hop breeding.

Keywords: *Humulus lupulus* L.; hop; *Podosphaera macularis* (Braun); powdery mildew; resistance; biochemical markers

KOMPONENTE ETERIČNEGA OLJA HMELJA (*Humulus lupulus*) KOT MARKERJI ODPORNOSTI NA HMELJEVO PEPELOVKO (*Podosphaera macularis*)

IZVLEČEK

V raziskavi so bila izvedena opazovanja poljske odpornosti 103 sort hmelja na hmeljevo pepelovko v treh letih, analizirana so bila eterična olja hmelja vseh sort z določenimi relativnimi deleži posameznih komponent ter njihove korelacije z oceno poljske odpornosti na hmeljevo pepelovko. Sedem markerjev, povezanih z občutljivostjo (vrhovi 29 (metil-5-metil-heksanoat), 30 (mircen), 34 (izo-amil-izo-butirat), 38 (1-8-cineol), 56 (metil-oktanoat), 88 (metil dekanoat) in 122 (nedeterminiran vrh)) in sedem povezanih z odpornostjo na hmeljevo pepelovko (piki 112 (santalen), 114 (germakren-D), 118 (alfa-selinen), 138 (kariofilen epoksid), 26, 135 in 158 (nedeterminirani piki)) so bili izbrani na osnovi pozitivnih ali negativnih korelacij s poljskimi ocenami odpornosti na hmeljevo pepelovko in prisotnostjo vrhov v eteričnem olju ekstremno občutljivih in odpornih sort. Število in vrednost markerjev povezanih z odpornostjo/občutljivostjo se je zmanjšala s povečanjem stopnje občutljivosti/odpornosti sort. Občutljive sorte na hmeljevo pepelovko večinoma vključujejo severno-ameriško dednino, medtem ko odpornejše sorte izvirajo iz evropske dednine. Analiza prisotnosti/odsotnosti izbranih markerjev kaže na praktično uporabnost odsotnosti markerjev povezanih z občutljivostjo, zlasti 30, 34 in 38 v žlahtnjenju hmelja v smeri odpornosti na hmeljevo pepelovko.

Ključne besede: *Humulus lupulus* L.; hmelj; *Podosphaera macularis* (Braun); hmeljeva pepelovka; odpornost; biokemični markerji

[1] Department for Plants, Soil and Environment, Slovenian Institute of Hop Research and Brewing, Žalec, Slovenia; Ph. D.; andreja.cerenak@ihps.si

[2] Savinjska 89, Žalec, Slovenia; Ph. D.

[3] Centre for Plant Biotechnology and Breeding, Biotechnical Faculty, University of Ljubljana, Ljubljana, Slovenia; Prof., Ph. D.

1 INTRODUCTION

Hop (*Humulus lupulus* L.) is a perennial plant, the yield of which (hop cones) is used mainly in the brewing industry. It is grown in monoculture, so it is exposed to high pressure from different pests and diseases. Hop powdery mildew (*Podosphaera macularis ssp. humuli* (Braun), formerly called *Sphaerotheca humuli* (DC.) Burrill) is one of the oldest known hop diseases, and it can be extremely prolific. Heavy infestations can completely destroy a crop. In 1997, over 1200 ha of hop fields were destroyed in the USA due to the planting of highly susceptible cultivars, despite years of quarantine efforts (Turechek et al., 2001; Ocamb et al., 1999). In Germany, it was a disease of little significance until Northern Brewer, a susceptible cultivar, was planted extensively. Quarantine restrictions have prevented the disease from becoming established in South Africa or Australasia.

Powdery mildew infections on leaves and bines do not generally result in essential damage, but do serve as a source of flower and cone infestations, which can cause serious economic damage on susceptible cultivars. High alpha cultivars, in particular, have been prone to show increased susceptibility to powdery mildew (Seigner et al., 2005). Hop powdery mildew infection reduces the content of alpha bitter acids by 12-25 % and thus also lowers the quality, not just the quantity of the yield (Krofta and Nesvadba, 2003).

One main aim of hop breeders is therefore to develop new cultivars with powdery mildew resistance, especially to reduce the amount of pesticides used to ensure top quality hop. The first hop cultivars possessing powdery mildew resistance were released in England (Darby, 1998b). Various American and German breeding programmes later also resulted in cultivars with good powdery mildew resistance. The Slovenian Institute of Hop Research and Brewing has bred 1 high alpha and 11 aroma cultivars that show moderate to good resistance levels for powdery mildew, 4 of which are planted on more than 95 % of Slovene hop fields. Additional important aims in hop breeding include resistance to downy mildew and wilt, while high yield, quantity and quality of resins and essential oils remain the major objectives, since hop is an important ingredient in the beer-brewing process.

To date, eight powdery mildew resistance genes have been reported (Darby, 1998a; Seefelder et al., 2006). Resistance to powdery mildew conferred by these genes can be overcome by the development of new pathotypes. The sexual form of powdery mildew enables new combinations of genes; as a result new pathogen genotypes can develop, causing a decline in plant resistance (Royle, 1978; Darby, 1998a). Molecular markers associated with R_2 (deriving from Wye Target) and R_{bu} (derived from Buket) genes for powdery mildew resistance have been developed (Seefelder et al., 2006). Such markers are applicable in marker assisted selection, which can shorten lengthily hop resistant breeding based on selection of resistance phenotypes.

It has been found that resistance to powdery mildew conferred by the R_B gene (derived from Yeoman and Wye Challenger) is related to the production of selinenes in essential oils (Liyanage, 1973; Darby, 1998b) and this led us to study correlations between essential oil compounds and powdery mildew resistance in different hop cultivars. Our main goal was to identify the essential oil compounds associated with different responses of hop cultivars to powdery mildew infection and to develop appropriate markers. We obtained 7 susceptibility markers and 7 resistance markers showing good correlation with the susceptibility/resistance of hop cultivars, which could be used in breeding.

2 MATERIAL AND METHODS

2.1 Material

We used a collection of 103 hop cultivars for the study: landraces, wild and cultivated hops from different hop-growing regions of the world (Australia, Belgium, Czech Republic, Denmark, England, France, Germany, Japan, New Zealand, Poland, Russia, Slovenia, South Africa, Serbia, USA and Ukraine). Two highly susceptible cultivars, Symphony and Yakima Cluster, perished in our hop collection because of disease and we therefore obtained essential oils from Tasmania and Oregon, respectively (Olson, 1998; Bobes et al., 1981).

2.2 Assessments of powdery mildew resistance of hop cultivars in the field

The analysed cultivars were cultivated in an experimental field under principles of good agriculture practise for a period of 3 years. Each cultivar was represented by 10 plants and the field was treated against pests (two spotted spider mites (*Tetranychus urtacae*), damson hop aphid (*Phorodon humuli* Schrank)) if the pest threshold was indicated. The field was not treated against fungal diseases, in order to gain reliable assessments of resistance to powdery mildew. The plants were visually inspected for symptoms of powdery mildew on leaves once per week. The most appropriate climatic conditions for disease development were in August. Resistance to powdery mildew was scored from 0 to 5 on collected technologically ripe cones (400/cultivar). Cultivars with no symptoms of

disease were graded 0, those with minimum symptoms 1 (≤ 10 % infected cones), more susceptible cultivars 2 (11-20 % infected cones), susceptible 3 (21-40 % infected cones), very susceptible 4 (41-60 % infected cones) and extremely susceptible 5 (more than 60 % of infected hop cones). The cultivars Symphony and Yakima Cluster were scored at 5 due to their known high susceptibility.

2.3 Preparation and analysis of hop essential oil

Analyses were performed on technologically ripe cones. The same number of cones from lower, middle and upper parts of all 10 plants was collected and average subsamples were used for analyses. After one month of storage at room temperature, the essential oil was distilled according to standard methods and specimens of the oil were analysed according to a standard GC procedure. Chromatographic analysis of essential oils recorded 187 peaks, shown as relative percentages (the sum of relative percentages of all 187 peaks of the chromatograph is 100). Eighty-eight peaks were determined by preparative chromatography combined with mass spectroscopy. In order to compare different quantities of individual peaks, relative percentages were converted into indexes. The index was defined as $X = (O_n/O_{Nmax}) \times 100$, where O_n is the relative percentage of the N-th constituent of the essential oil and O_{Nmax} is the maximum relative percentage for the same constituent in all analysed cultivars.

The data were analysed by factor analysis (Spearman, 1905) and the correlation between the score for powdery mildew and the relative percentage of essential oil compounds was calculated for each year. Potential markers were selected from among the indexes that were significant in positive or negative correlation with powdery mildew scores in all three years.

3 RESULTS

Forty-six out of 88 peaks showed significant correlations at r= 0.15 (p= 0.05), 29 peaks were in negative and 17 in positive correlation with the scores of powdery mildew. Seven of the peaks with negative correlation were selected as resistance markers, since they were determined in the essential oil of resistant cultivars with a score of 0 (Cascade, Wye Target, Serebrjanka and Strisselspalt). Seven susceptibility markers were selected from peaks with positive correlation present in the essential oil of extremely susceptible cultivars which scored 5 (Symphony, Yakima Cluster and Galena). The resistance markers for powdery mildew selected in this way are: 112 (santalene), 114 (germacrene-D), 118 (alpha-selinene), 138 (cariophylene epoxide), 26, 135 and 158 (undetermined peaks), and the susceptibility markers are: 29 (methyl-5-methyl-hexanoate), 30 (myrcene), 34 (iso-amyl-iso-butyrate), 38 (1-8-cineole), 56 (methyl-octanoate), 88 (methyl decanoate) and 122 (undetermined peak).

Table 1 shows the 103 cultivars included in the research with field susceptibility estimates obtained over 3 years. The cultivars are divided into 6 groups. Group 0 consists of 7 resistant cultivars (6.8 % of 103 analysed cultivars). Minimum symptoms of infection were observed on 12 cultivars placed in group 1 (11.6 %). The majority of genotypes (60; 58.3 %) belong to group 2, more susceptible genotypes to group 3 (10; 9.7 %) and 4 (12; 11.6 %) while 3 genotypes (2.9 %) are in the group of most susceptible cultivars.

Selected peaks are presented in Table 1 as indexes estimated over three years. Indexes above a certain threshold (25, 40 or 50) were considered to be markers (bold) related to the susceptibility or resistance of hop to powdery mildew.

Markers 26, 112, 114, 118, 135, 138 and 158 were found in groups 0 and 1 of resistant cultivars. Two to five markers were present in the essential oil of all cultivars except Wye Northdown, which showed only one marker, indicating that the number of markers does not indicate the level of resistance. The cultivar Cascade, with inbred inheritance of Fuggle and Serebrjanka cultivars, is resistant in various hop-growing regions.

The number and value of the resistance markers decreased as the level of susceptibility of cultivars increased, achieving very low indexes in group 5. Marker 118 (alfa-selinen) had indexes above the threshold in the majority of resistant cultivars (groups 0 and 1) while it had a very low index in the groups scoring 4 and 5. Similarly, markers 138 and 158 indicate resistance to powdery mildew, since they presented with low indexes in susceptible groups 4 and 5.

Susceptibility markers 29, 30, 34, 38, 56, 88 and 122 had low indexes in resistant cultivars, while their indexes noticeably increased in susceptible cultivars, reaching index 100 in some cases in groups 4 and 5. The absence of resistance markers and presence of markers 56 and 88 was very characteristic of the three maximum susceptible cultivars: Symphony, Yakima Cluster and Galena. The genotype Symphony had 5 susceptibility markers, of which 56 and 122 had extremely high indexes. Symphony is known to be a highly susceptible cultivar in the USA, where a serious economic disaster occurred in hop fields in 1997 (Ocamb et al., 1999). The essential oil of susceptible old American cultivar Yakima Cluster includes 5 susceptibility markers, of which marker 30 had the highest index. Galena, the third cultivar in group 5, had all seven susceptibility

markers, with extremely high values of markers 34 and 88.

***Table 1**: Evaluation of susceptibility of cultivars to powdery mildew with values of relevant markers; indexes are bolded and thresholds are italic.*

Cultivar	Peak / Field assesment	**26** *25*	**112** *25*	**114** *25*	**118** *25*	**135** *40*	**138** *40*	**158** *40*	**29** *40*	**30** *50*	**34** *40*	**38** *50*	**56** *40*	**88** *40*	**122** *40*
Cascade	0	9	**82**	23	20	**100**	38	27	17	26	32	9	8	5	0
Wye Target	0	22	3	**57**	12	12	**57**	**83**	2	49	36	43	25	38	6
Serebrjanka	0	4	**27**	**64**	**33**	15	**100**	**78**	5	36	33	9	12	3	6
Pride of Ringwood	0	0	**100**	**100**	**100**	15	**100**	**78**	0	43	8	10	30	33	4
Nadwislansky	0	0	0	**45**	23	35	**87**	**72**	26	40	0	20	14	14	16
Univerzal	0	0	20	**32**	13	17	**60**	**40**	0	39	2	0	19	12	10
Strisselspalt	0	**27**	**36**	**53**	**41**	30	13	14	12	45	4	20	17	4	4
Iwanovecky	1	0	**46**	24	11	24	38	**42**	5	32	5	27	14	14	11
Zlatan	1	0	0	**29**	11	13	**42**	33	0	20	0	30	14	8	16
Tutsham	1	0	0	**71**	**100**	**54**	5	25	10	22	4	36	6	1	3
Kogneao	1	13	**64**	**60**	**39**	33	0	27	19	30	2	27	10	1	3
Omega	1	0	**100**	**75**	**69**	7	15	28	14	18	15	40	16	0	5
Pioneer	1	**36**	**41**	**44**	**33**	2	3	29	0	49	28	27	8	18	4
First Gold	1	**82**	**44**	**50**	**48**	6	2	20	0	**62**	35	27	11	6	4
Herald	1	**100**	**46**	**53**	**48**	6	1	19	0	47	38	**82**	11	5	4
Wye Saxon	1	**77**	**36**	**35**	**33**	10	8	23	0	**56**	20	**90**	11	4	3
Wye Challenger	1	0	**29**	**36**	**51**	4	4	31	2	45	**56**	**60**	23	10	5
Wye Northdown	1	4	0	**25**	8	4	7	16	0	**57**	**48**	40	22	4	4
Wye Viking	1	**27**	12	**25**	18	10	4	29	17	**70**	**40**	**70**	22	4	5
Hallertauer MTF	2	4	6	**39**	8	16	**41**	**43**	14	37	13	20	14	3	4
Urožajni	2	0	0	**26**	20	21	29	**44**	2	36	1	36	0	0	0
White Bine	2	0	**49**	**67**	**47**	21	**52**	35	5	26	20	10	9	0	2
Emerald	2	9	13	**51**	**39**	33	6	25	33	39	33	27	8	3	11
Star	2	0	14	**29**	7	**72**	**100**	12	10	30	14	45	9	1	5
Backa	2	4	3	**35**	10	**100**	37	19	14	26	6	27	7	4	3
Chang bei 2	2	4	0	**46**	22	17	36	**49**	14	43	3	20	27	9	4
Early Bird Golding	2	**40**	15	**27**	8	11	4	11	0	38	11	45	11	3	4
Eastwell Golding	2	4	5	**29**	7	15	13	13	0	39	5	45	14	6	4
Mathon	2	0	6	**30**	14	10	7	15	0	23	13	40	16	4	6
Fuggles	2	4	0	**25**	6	9	10	12	7	33	20	40	9	2	4
Savinjski golding	2	5	**26**	**25**	8	10	10	8	7	39	17	36	9	1	5
Saladin	2	0	0	**27**	8	19	8	23	2	39	13	45	7	1	5
Orion	2	13	10	**38**	8	10	14	28	14	43	25	30	9	3	10
Osvaldov klon 126	2	0	0	**28**	6	9	9	13	10	39	16	40	7	0	4
Osvaldov klon 72	2	0	0	**25**	11	23	16	36	0	38	0	0	20	13	13
Coobs	2	9	3	**32**	9	11	8	15	2	35	6	30	13	4	4
Nordgard 978	2	0	5	**36**	10	17	37	36	21	30	26	27	36	6	10
Groene Bel	2	0	5	**32**	12	9	23	18	7	31	15	27	4	0	1
Spalter	2	0	0	18	14	20	19	**50**	5	36	3	27	17	10	10
Sirem	2	0	0	16	12	27	13	**50**	7	42	2	27	12	14	9
Kostromsky	2	0	0	15	8	26	26	**53**	7	42	1	27	17	9	16
Žitomirski klon34	2	0	0	12	11	28	16	**50**	7	37	1	36	13	11	11
Žitomirski klon 18	2	0	0	5	**26**	**46**	14	38	0	30	0	20	12	6	0
Tardif de Bourgogne	2	0	0	21	12	22	**43**	33	26	33	0	10	27	16	16
Žateški pol.červenjak	2	0	21	20	12	21	**48**	34	5	47	4	27	13	13	10
Hallertauer Gold	2	**32**	8	18	8	18	17	33	36	40	18	45	30	8	6
Mt. Hood	2	**73**	0	**43**	10	26	**79**	**100**	**45**	27	**57**	0	14	29	3
Ringwood special	2	0	8	**28**	16	24	**99**	**55**	**48**	43	5	27	28	34	11
Yeoman	2	**45**	**26**	**39**	**52**	12	5	17	21	49	**51**	**82**	11	1	4
Comet	2	4	**51**	**34**	**58**	**41**	17	38	14	**55**	12	**50**	8	8	12
Kirin 1	2	4	**36**	**64**	**39**	**43**	21	23	0	47	**41**	27	10	3	2
Hueller Biterer	2	9	**41**	**70**	**31**	35	5	20	29	**66**	33	30	14	4	13
Chang bei 1	2	0	**38**	**43**	**34**	10	13	26	2	35	**45**	27	21	6	8

Zenith	2	0	**43**	**55**	**72**	7	4	17	7	33	17	**50**	17	4	5
Neuroter	2	0	**26**	**29**	13	31	24	**50**	**45**	28	0	20	17	13	20
College Cluster	2	0	**40**	**31**	12	7	14	20	36	42	**57**	**90**	16	8	4
Poljski klon 34	2	0	**25**	**31**	12	16	25	38	**50**	32	3	20	22	15	15
Celeia	2	0	24	**39**	**26**	9	15	14	10	**63**	6	39	22	4	5
Cerera	2	0	22	**34**	**27**	0	15	7	12	**58**	16	39	18	3	0
Aromat	2	0	24	**26**	11	27	27	38	**43**	31	0	20	16	11	15
Wuertemberger	2	4	13	**36**	12	16	13	38	12	30	4	20	9	3	1
Saazer	2	0	**29**	13	27	28	52	22	2	20	**45**	26	38	0	4
Perle	2	5	3	**28**	7	15	7	20	2	45	23	**50**	7	4	8
Nordgard 1478	2	0	15	**26**	8	13	25	21	10	37	22	**55**	14	3	5
Sara	2	**36**	**64**	9	**61**	6	10	18	21	49	18	**70**	1	0	0
Poljski klon 12	2	0	0	**26**	7	8	6	12	2	32	29	**50**	7	0	4
Kruglak Siriak	2	0	0	17	12	29	21	**48**	**64**	**40**	2	27	19	12	16
Brausteren	2	**31**	8	**31**	6	11	3	28	2	**60**	29	**50**	8	3	5
Record	2	9	8	**26**	7	16	10	28	2	**51**	26	**70**	13	3	3
Estera	2	0	0	**30**	9	15	5	11	2	**51**	24	**55**	9	0	6
Buket	2	4	10	18	8	6	14	25	19	**64**	29	40	32	4	5
Hallertauer tradition	2	0	10	21	4	11	32	20	7	**62**	21	40	32	6	0
Nugget	2	18	5	18	19	10	2	4	5	**65**	35	36	26	28	7
Smooth Cone	2	0	10	16	9	11	11	12	**50**	**62**	29	40	37	11	3
Cekin	2	14	18	16	3	10	5	3	0	47	15	**60**	22	3	4
Bobek	2	0	5	13	7	5	4	7	14	**67**	18	**55**	33	6	4
Aurora	2	0	0	12	11	11	5	4	5	**55**	22	**64**	34	8	6
Northeren Brewer	2	0	3	20	7	6	2	5	2	**56**	27	**64**	8	4	3
Southeren Brewer	3	5	**62**	18	19	31	33	**65**	**54**	**58**	39	33	14	25	22
Spalt Select	3	0	**85**	17	13	21	14	**65**	**45**	**55**	5	**55**	3	0	0
First Choice	3	0	**38**	**45**	**62**	13	4	12	17	**100**	9	**64**	17	5	4
Golden Star	3	0	**27**	**55**	**34**	5	17	18	0	**55**	**62**	27	13	4	3
Kirin 2	3	0	**25**	**51**	**34**	2	10	23	2	**65**	**66**	20	8	3	3
Petrovački červenjak	3	0	0	**32**	9	26	34	**45**	**55**	24	0	20	33	19	18
Bullion	3	0	8	19	11	23	14	19	29	**80**	**40**	20	14	18	4
Willamatte	3	0	5	18	6	6	7	3	10	**68**	**43**	45	7	3	2
Blisk	3	0	0	0	5	5	8	9	24	**65**	30	20	10	5	3
Fukujutaka	3	0	12	14	3	0	7	30	17	**85**	18	30	7	10	3
Kitamidori	4	0	0	22	4	13	25	21	17	41	22	**100**	32	5	1
Dunav	4	9	3	18	8	9	9	31	10	**70**	26	**73**	22	5	4
Neoplanta	4	0	13	**28**	7	12	12	27	19	**56**	31	**50**	2	0	2
Vojvodina	4	9	13	21	5	10	6	31	0	**71**	26	**73**	9	5	4
Cicero	4	0	18	**29**	4	20	7	17	17	**65**	24	**70**	10	2	6
Magnum	4	0	23	8	2	16	5	26	**100**	**77**	19	**50**	27	16	21
Calli Cross	4	9	**31**	16	5	13	2	13	38	**75**	**41**	**50**	29	**69**	5
Keyworth Midseason	4	13	10	**25**	17	24	29	35	31	**70**	**76**	**73**	3	4	2
Apolon	4	0	0	0	5	4	11	8	36	**71**	13	20	24	18	9
Brewers Gold	4	0	1	14	12	11	21	21	31	**100**	**61**	27	18	11	2
Atlas	4	0	0	12	7	7	15	14	31	**77**	**100**	20	0	10	4
Ahil	4	0	0	12	9	9	10	22	36	**71**	**67**	40	17	11	3
Symphony	5	7	12	10	4	7	0	23	19	**65**	**56**	30	**100**	**84**	**100**
Yakima Cluster	5	0	15	10	5	7	3	18	17	**100**	**88**	**90**	**52**	**96**	7
Galena	5	0	15	14	12	18	2	28	**98**	**68**	**100**	**80**	**68**	**100**	**40**

Susceptibility markers appeared in half of the cultivars in group 1 but they were more frequent in group 2. Group 2 can be divided into 3 subgroups: subgroup 2a containing 27 cultivars with at least 1 resistance and no susceptibility marker; subgroup 2b with 24 cultivars showing both types of markers, and subgroup 2c (8 cvs.) with only susceptibility markers. In groups 3, 4 and 5, the number of susceptibility markers with high values increased. For example, marker 30 achieved extreme values in susceptible cultivars scored with 4 or 5. The same is true of markers 34 and 38, in which indexes increased in relation to susceptibility.

Analysis of the presence/absence of selected markers showed that the absence of susceptibility markers, particularly 30, 34 and 38, can be of practical value in resistance hop breeding. These markers were not found in cultivars scored 0, and in less than half of the cultivars in groups 1 and 2 (33 cvs. out of 72).

4 DISCUSSION

Resistance breeding is one of the most important aims in developing new hop cultivars. Marker assisted selection is an important tool in modern breeding, contributing to a shorter period required for breeding. Secondary metabolites are known to be disease defence compounds and biochemical markers for downy mildew and hop damson aphid have been developed in hop (Kralj et al., 1998). In the present work, we analysed the link between essential oil compounds and the resistance/susceptibility of hop cultivars to powdery mildew. Powdery mildew is a significant disease, the appearance of which depends on climatic conditions, and selection for resistance in the field can therefore be unreliable. Direct assessments of infection on cones are laborious, so the reported biochemical markers can significantly speed up and simplify the search for powdery mildew resistant genotypes.
We assessed disease on 103 cultivars from the world germplasm collection. Cultivars were divided into 6 disease groups, although it is very difficult to make a clear distinction among groups with semi-susceptible cultivars (groups 2 and 3), while resistant (groups 0 and 1) and highly susceptible (groups 4 and 5) cultivars were clearly distinguished. The assignment of the cultivars into disease groups depended on the resistance/susceptibility of cultivars to *S. humuli* pathotypes present in our conditions.

Based on field assessments of hop resistance to powdery mildew and chromatographic analysis of their essential oils in the hop cones, 7 susceptibility markers and 7 resistance markers were identified. These markers are differently distributed and have different values among the analysed cultivars. Accordingly, a cultivar was considered resistant only when susceptibility markers were absent and resistance markers with high indexes were present (Table 1). Similarly, a cultivar was classified as susceptible when susceptibility markers were present and resistance markers were absent or had very low indexes. These results can be of practical value in breeding, since it has been shown that the absence of susceptibility markers, particularly 30, 34 and 38, can indicate the resistance of a hop genotype.

Our results also support the hypothesis that selinenes are involved in powdery mildew resistance (Liyanage, 1973; Darby, 1998b), since alpha-selinene is one of the resistance markers (marker 118) detected in our analysis. This marker was absent in susceptible cultivars in groups 4 and 5, although its presence in resistant cultivars was not consistent and it cannot therefore be used as a reliable marker.

Cultivars in groups 4 and 5 mainly contain North American germplasm according to studies of genetic diversity of hop genotypes (Sustar-Vozlič et al., 1999, Stajner et al., 2007). On the other hand, resistant cultivars belong to European hops, such as Czech Saazer, traditional German hops (Strisselspalt) and many cultivars of English origin. The same relation between susceptibility to downy mildew and the origin of germplasm was made in a previous paper on the determination of markers related to resistance to downy mildew (Kralj et al., 1998).

The above results showed a link between the content of essential oil compounds and resistance to powdery mildew, which was the basis for detection of chemical markers. These markers can be used in resistance breeding, by essential oil analysis of the breeding material and selection of resistant plants based on high indexes of resistance markers and low indexes of susceptibility markers.

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6 REFERENCES

Bobes, I., Florea, N., Otoin, M. (1981): Buletinul Agronomic. Cluj – Napora, *Agricultura*, 35: 103-107.

Darby, P. (1998 a): The symptoms and biology of Hop Powdery Mildew. In: Hop powdery Mildew Electronic Symposium, presentation from the 1998 US Hop Industry Joint Meeting, Yakima, Washington, January 19-23, http://wwwscisoc.org/hpmes/darby.htm.

Darby, P. (1998 b): UK Research Offer Advice on Hop Powdery Mildew. *Brewers Digest*, 2: 24-26.

Kralj, D., Kač, M., Dolinar, M., Žolnir, M., Kralj, S. (1998): Marker-assisted hop (*Humulus lupulus* L) breeding. *Monatsschrift für Brauwissenschaft*, 7/8: 111–119.

Krofta, K., Nesvadba, V. (2003): How hop powdery mildew influences the quality of hops and beer? In: *Proceedings of the Scientific Commission*, pp. 58-62. Ed. Seigner E. Dobrna – Žalec, Slovenia: International Hop Growers Convention.

Liyanage, A., De, S. (1973): Studies on resistance and overwintering in hop powdery mildew (*Sphaerotheca Humuli*). PhD Thesis, University of London, Wye College.

Ocamb, C.M., Klein, R., Barbour, J., Griesbach, J., Mahaffee, W.F. (1999): First Report of Hop Powdery Mildew in the Pacific Northwest. Disease Notes. *Plant Disease*, 83: 11.

Olson, R. (1998): Hop Damage Costly. Southern Draft Brewer News, December 1997/Januar 1998.

Royle, D.J. (1978): Powdery Mildew of the Hop. In: The Powdery Mildews (Ed. by D.M. Spencer), Academic Press, London: 381-409.

Seefelder, S., Lutz, A., Seigner, E. (2006): Development of molecular markers for powdery mildew resistance support breeding for high quality hops. *Monatsschrift für Brauwissenschaft*, 5/6: 100-102.

Seigner, E., Lutz, A., Radic-Miehle, H., Seefelder, S. (2005): Breeding and development of hop varieties at the Hop research center Hüll. In: *Proceedings of the Scientific Commission*, pp. 18-22. Ed. Seigner E. George, South Africa: International Hop Growers Convention.

Spearman, C. (1905): General intelligence objectively determined and measured. *American Journal of Psychology*, 15: 201-93.

Stajner, N., Satovic, Z., Cerenak, A., Javornik, B. (2007): Genetic structure and differentiation in hop (*Humulus lupulus* L.) as inferred from microsatellites. *Euphytica* DOI 10.1007/s10681-007-9429-z.

Sustar-Vozlic, J., Javornik, B. (1999): Genetic relationships in cultivars of hops, *Humulus lupulus* L., as determined by RAPD analysis. *Plant Breeding*, 118: 175-181.

Turechek, W.W., Mahafee, W.F., Ocamb, C.M. (2001): Development of Managment Strategies for Hop Powdery Mildew in the Pacific Northwest. *Plant Health Progress* doi: 10.1094/PHP-2001-0313-01-RS.

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Distribution of Thysanoptera species and their host plants in Croatia

Emilija RASPUDIĆ[1], Marija IVEZIĆ[2], Mirjana BRMEŽ[3], Stanislav TRDAN[4]

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ABSTRACT

Sampling of thrips species and their host plants were carried out from 1993 to 1996 on 111 localities in Croatia. Samples of thrips were taken from 235 different plant species. 33 thrips species from suborder Terebrantia and 14 thrips species from suborder Tubulifera were found in research. The most abundant species were onion thrips (*Thrips tabaci*) and flower thrips (*Frankliniella intonsa*), which were found on host plants from 30 and 29 botanical families, respectively. Six new species for Croatia was recorded: *Aeolothrips melaleucus*, *Oxythrips bicolor*, *Stenothrips graminum*, *Thrips linarius*, *Liothrips vaneeckei*, and *Poecilothrips albopictus*.

Key words: thrips, Thysanoptera, host plants, sampling, Croatia

RESARJI (Thysanoptera) IN NJIHOVE GOSTITELJSKE RASTLINE NA HRVAŠKEM

IZVLEČEK

V obdobju 1993-1996 smo na 111 lokacijah na Hrvaškem vzročili resarje (Thysanoptera) na različnih vrstah gostiteljskih rastlin. Vzorce resarjev smo nabrali na 235 vrstah rastlin. 33 vrst resarjev, najdenih v raziskavi, je pripadalo podredu Terebrantia, 14 vrst pa podredu Tubulifera. Najbolj razširjeni vrsti sta bili tobakov resar (*Thrips tabaci*), ki smo ga našli na rastlinskih vrstah iz 30 botaničnih družin, in resar *Frankliniella intonsa*, ki je bil ugotovljen na gostiteljskih rastlinah iz 29 botaničnih družin. V raziskavi smo potrdili razširjenost 6 vrst resarjev, ki na Hrvaškem dotlej še niso bile najdene: *Aeolothrips melaleucus*, *Oxythrips bicolor*, *Stenothrips graminum*, *Thrips linarius*, *Liothrips vaneeckei* in *Poecilothrips albopictus*.

Ključne besede: resarji, Thysanoptera, gostiteljske rastline, vzorčrenje, Hrvaška

1 INTRODUCTION

The order Thysanoptera is homogenous group of insects with characteristic wings – they have long fringe and very poor nervature. The adults are only few mm long and their detection is not easy. Up to date, more than 5000 species from two suborders - Terebrantia and Tubulifera - and 8 families – Merothripidae, Aeolothripidae, Heterothripidae, Adiheterothripidae, Thripidae, Uzelothripidae, Fauriellidae, and Phlaeothripidae, are described. 93 % of species belong to the families Thripidae and Phlaeothripidae (Mound, 1997) and their representatives are also the most common in Croatia and its neighbouring countries (Trdan *et al.*, 2003). The most important pests from Thysanoptera order – e.g. *Frankliniella occidentalis*

[1] Josip Juraj Strossmayer University in Osijek, Faculty of Agriculture, Trg Svetog Trojstva 3, HR-31000 Osijek, Croatia; email: emilija.raspudic@pfos.hr

[2] ibid.

[3] ibid.

[4] University of Ljubljana, Biotechnical Faculty, Dept. of Agronomy, Jamnikarjeva 101, SI-1111 Ljubljana

(Pergande), *Thrips tabaci* Lindeman, *Thrips palmi* Karny and *Scirtothrips dorsalis* Hood - belong to Thripidae family (Mound, 1997). In Croatia, up to now thrips fauna was investigated by Kovačević (1964), zur Strassen (1981, 1984), Ciglar *et al*. (1984, 1990), Šimala (1991), Raspudić (1996) and Andjus (1997).

Knowledge on host plants of thrips is important, since many polyphagous species and viruses they transmit can survive on different wild-growing plants also out of growing season of the plants (in most cases the cultivated plants), in which this pests caused the highest damage (Jenser *et al*., 2007). Until now, in Croatia and in some of its neighbouring countries many authors investigated distribution of Thysanoptera and their host plants: Jenser (1986, 1990), Jenser and Tusnádi (1989), Jenser and Balogh (1992), Masten (1983), Ciglar *et al*. (1984, 1990), Janežič (1991), Šimala (1991), Janežič and Maček (1993), Raspudić (1999), and Trdan (2002, 2003). The aim of this research was to identify thrips species and their host plants in Croatia, since the previous data from the same country was connected only with the individual thrips species.

2 MATERIALS AND METHODS

Monitoring of thrips fauna was carried out in Croatia from 1993 to 1996. Total of 662 samples – most of them were collected outdoors - from 235 different plant species were taken from 111 localities. Thrips sampling was done using standard thysanopterological instruments (Raspudić, 1996; Trdan, 2002). The samples were taken from agricultural crops, plants in the garden, channels, meadows, bushes and forests. Determination of thrips was carried out in the Entomological Laboratory (Josip Juraj Strossmayer University in Osijek, Faculty of Agriculture) on the base of 1058 permanent slides. Determination was made according to morphological keys of Jenser (1982), Okumura and Papp (1991), and Moritz (1994). Determination of plant species was done by Prof. Ana Skender (Josip Juraj Strossmayer University in Osijek, Faculty of Agriculture), according to morphological keys of Ehrendorfer (1973) and Domac (1994).

3 RESULTS

Results on determination of thrips species and their hosts plants are presented in chapters 3.1 and 3.2, in which Thysanoptera and their host plant species are presented at family levels.

3.1 Suborder Terebrantia

3.1.1 Family Aeolothripidae

3.1.1.1 *Aeolothrips intermedius* Bagnall, 1934

Apiaceae: *Daucus carota* L.
Asteraceae: *Cirsium arvensis* (L.) Scop., *Helianthus annuus* L., *Centaurea cristata* Bartl.
Brassicaceae: *Sinapis arvensis* L., *Rorippa austriaca* (Cr.) Bess., *Raphanus sativus* L.
Caprifoliaceae: *Sambucus nigra* L.
Chenopodiaceae: *Beta vulgaris* L. *var. saccharifera* Lange,
Fabaceae: *Trifolium campestre* Schreb, *Glycine max* (L.) Merr., *Trifolium pratense* L., *Phaseolus vulgarea* L., *Trifolium repens* L.
Iridaceae: *Gladiolus gandavensis* van Houtte.
Papaveraceae: *Papaver rhoeas* L., *Papaver somniferum* L.
Poaceae: *Zea mays* L.
Polygonaceae: *Rumex obtusifolius* L.
Punicaceae: *Punica granatum* L.
Rosaceae: *Rosa canina* L.
Solanaceae: *Nicotiana tabacum* L.

3.1.1.2 *Aeolothrips melaleucus* Haliday, 1852

Caprifoliaceae: *Sambucus ebulus* L.
Corylaceae: *Corylus avellana* L.
Fabaceae: *Glycine max* (L.) Merr.
Puncaceae: *Punica granatum* L.
Rosaceae: *Prunus persica* (L.) Batsch
Vitaceae: *Vitis vinifera* L.

3.1.1.3 *Aeolothrips ericae* Bagnall, 1920

Poaceae: *Zea mays* L.

3.1.1.4 *Melanthrips pallidior* Priesner, 1919

Chenopodiaceae: *Spinacia oleracea* L.
Brassicaceae: *Raphanus sativus* L., *Rorippa austriaca* (Cr.) Bess.

3.1.1.5 Aeolothripidae larvae

Apiaceae: *Daucus carota* L.
Asteraceae: *Cirsium arvense* (L.) Scop., *Tripleurospermum inodorum* (L.) C.H. Schultz
Brassicaceae: *Raphanus landra* Moretti
Fabaceae: *Coronilla varia* L., *Medicago sativa* L., *Trifolium repens* L., *Dorycnium herbaceum* Vill., *Melilotus alba* Med.
Poaceae: *Avena sativa* L., *Zea mays* L., *Sorgum bicolor* (L.) Moench.
Polygonaceae: *Rumex crispus* L., *Polygonum lapathifolium* L.
Rubiaceae: *Galium mollugo* L.

3.1.2 Family Thripidae

3.1.2.1 *Aptinothrips rufus* (Haliday, 1836)

Fabaceae: *Coronilla varia* L.
Poaceae: *Bromus* sp., *Melica transsilvanica* Schur, *Triticum aestivum* L., *Lolium perenne* L.

3.1.2.2 *Aptinothrips stylifer* Trybom, 1894

Brassicaceae: *Capsella bursa-pastoris* (L.) Med.
Fabaceae: *Medicago sativa* L.
Malvaceae: *Malva sylvestris* L.
Poaceae: *Triticum aestivum* L.
Solanaceae: *Petunia hybrida*

3.1.2.3 *Anaphothrips obscurus* (O.F. Müller, 1776)

Ranunculaceae: *Clematis vitalba* L.

3.1.2.4 *Ceratothrips ericae* (Haliday, 1836)

Apiaceae: *Anethum graveolens* L., *Daucus carota* L.
Asteraceae: *Inula britannica* L., *Inula crithmoides* L., *Calendula officinalis* L.,
Cichoriaceae: *Crepis setosa* Hall.f. *Taraxacum officinale* Web., *Crepis biennis* L.,*Cichorium intbus* L., *Sonchus arvensis* L., *Lactuca sativa* L., *Picris* sp., *Picris hieracioides* L., *Chondrilla juncae* L., *Sonchum arvensis* L., *Sonchus* sp.
Convolvulaceae: *Convolvulus arvensis* L.
Cucurbitaceae: *Cucurbita pepo* L.
Dipsaceae: *Scabiosa ochroleuca* L.
Iridaceae: *Gladiolus gandavensis* van Houtte
Lamiaceae: *Nepeta cataria* L.
Poaceae: *Zea mays* L., *Deschampisia flexuosa* (L.) Trin.
Rosaceae: *Spirea salicifolia* L.
Verbanaceae: *Vitex agnus castus* L.

3.1.2.5 *Chirothrips aculeatus* Bagnall, 1927

Fabaceae: *Trifolium repens* L.
Poaceae: *Lolium perenne* L.

3.1.2.6 *Chirothrips manicatus* Haliday, 1836

Asteraceae: *Erigeron annuus* L.
Brassicaceae: *Sinapis arvensis* L..
Lamiaceae: *Nepeta pannonica* L.
Malvaceae: *Malva alcea* L.
Poaceae: *Dactylis glomerata* L., *Calamagrostis epigeios* (L.) Roth, *Zea mays* L, *Lolium perenne* L., *Sorgum halepense* (L.) Pers, *Sorgum bicolor* (L.) Moench, *Festuca heterophylla* Lam., *Deschampisia flexuosa* (L.) Trin.
Rosaceae: *Malus* sp.

3.1.2.7 *Drepanothrips reuteri* Uzel, 1895

Asteraceae: *Artemisia vulgaris* L.

3.1.2.8 *Frankliniella intonsa* (Trybom, 1895)

Apiaceae: *Daucus carota* L., *Anethum graveolens* L.
Apocynaceae: *Nerium oleander* L.
Asteraceae: *Matricaria chamomilla* L., *Centaurea cyanus* L., *Achillea millefolium* L., *Calendula officinalis* L., *Erigereon annuus* (L.) Pers., *Helianthus annuus* L., *Cirsium arvense* (L.) Scop., *Tagetes patulus* L., *Serratula tinctoria* L., *Solidago gigantea* Ait., *Centaurea jacea* L., *Leucanthemum ircutianum* DC, *Artemisia vulgaris* L., *Dahlia* sp., *Cinia* sp.
Brassicaceae: *Brassica napus var. oleifera* DC., *Cardaria draba* (L.) Desv., *Sinapis arvensis* L., *Rorippa sylvestris* (L.) Bess, *Raphanus landra* Moretti, *Raphanus raphanistrum* L., *Capsella bursa-pastoris* (L.) Med., *Cheiranthus cheiri* (L.)
Caryophyllaceae: *Melandrium album* (Mill.) Garcke, *Lychnis flos-cuculi* L., *Moenchia mantica* (L.) Bartl., *Sambucus nigra* L. *Sambucus ebulus* L., *Dianthus* sp.
Chenopodiaceae: *Beta vulgaris var. saccharifera* Lange
Cichoriaceae: *Taraxacum officinale* Web., *Crepis tectorum* L., *Crepis jacquini* Tausch, *Cichorium intybus* L.
Convolvulaceae: *Convolvulus arvensis* L.
Cucurbitaceae: *Cucumis melo* L., *Cucumis sativus* L., *Cucurbita pepo* L.
Cupressaceae: *Tuja* sp.
Fabaceae: *Phaseolus vulgaris* L., *Trifolium pratense* L., *Trifolium repens* L, *Trifolium campestre* Schreb., *Astragalus glycyphyllos* L., *Pisum sativum* L., *Melilotus officinalis* (L.) Pall., *Lathyrus tuberosus* L., *Vicia grandiflora* Scop., *Glycine max* (L.) Merr, *Mentha* sp., *Medicago sativa* L., *Vicia cracca* L., *Trifolium arvense* L.
Geraniaceae: *Pelargonium* spp.
Hypericaceae: *Hypericum perforatum* L.
Iridaceae: *Gladiolus gandavensis* van Houtte
Lamiaceae: *Salvia officinalis* L., *Vicia cracca* L., *Medicago sativa* L., *Scutellaria hastifolia* L., *Stachys annua* (L.)
Liliaceae: *Allium* sp, *Lilium* sp., *Colchicum autumnale* L.
Lytraceae: *Lytrum salicaria* L.
Malvaceae: *Malva alcea* L.
Onagraceae: *Fuschia* sp.
Papaveraceae: *Papaver rhoeas* L.

Poaceae: *Hordeum murinum* L., *Triticum aestivum* L., *Zea mays* L.
Polyonaceae: *Polygonum lapathifolium* L.
Plantaginaceae: *Plantago altissima* L., *Plantago major* L.
Ranunculaceae: *Ranunculus acris* L., *Ranunculus repens* L., *Ranunculus arvensis* L. *Clematis recta* L.
Rosaceae: *Rosa* sp., *Potentilla reptans* L., *Rosacanina* L., *Potentilla inclinata* Vill., *Rubus* sp., *Fragaria* sp.
Saxifragaceae: *Hydrangea hortensis* Sieb.
Scrophulariaceae: *Antirrhinum majus* L., *Linaria vulgaris* Mill.
Solanaceae: *Solanum tuberosum* L., *Lycopersicon esculentum* Mill., *Nicotiana tabacum* L., *Capsicum annuum* L., *Petunia hybrida*
Violaceae: *Viola tricolor* L.

3.1.2.9 *Frankliniella occidentalis* (Pergande, 1895)
Araceae: *Cala palustris* L.
Apiaceae: *Capsicum annuum* L.
Asteraceae: *Helianthus annuus* L.,*Chrysanthemum sinense* L.
Brassicaceae: *Brassica oleracea var. botrytis* L.
Caryophyllaceae: *Stellaria media* (L.) Vill.
Cichoriaceae: *Taraxacum officinale* Web.
Fabaceae: *Galega officinalis* L.
Geraniaceae: *Pelargonium peltatum* L.
Onagraceae: *Plobium hirsutum* L.
Rosaceae: *Rosa* sp., *Fragaria* sp.
Solanaceae: *Solanum melongen* L, *Capsicum annuum* L.

3.1.2.10 *Frankliniella pallida* (Uzel, 1895)
Cichoriaceae: *Cichorium intybus* L.
Fabaceae: *Lathyrus tuberosus* L.
Poaceae: *Zea mays* L.
Rubiaceae: *Galium verum* L.
Scrophulariaceae: *Verbascum nigrum* L.

3.1.2.11 *Frankliniella tenuicornis* (Uzel, 1895)
Asteraceae: *Calendula officinalis* L., *Inula helenium* L.
Chenopodiaceae: *Beta vulgaris var. saccharifera* Lange
Fabaceae: *Trifolium repens* L., *Medicago sativa* L., *Glycine max* (L.) Merr.
Iridaceae: *Gladiolus gandavensis* van Houtte.
Poaceae: *Zea mays* L.
Solanaceae: *Nicotiana tabacum* L., *Capsicum annuum* L.

3.1.2.12 *Kakothrips robustus* (Uzel, 1895)
Fabaceae: *Lathyrus tuberosus* L., *Vicia cracca* L., Coronilla varia L., *Coronilla varia* L., *Medicago sativa* L. *Limothrips cerealium* Haliday, 1836
Asteraceae: *Cirsium arvensis* (L.) Scop.
Convolvulaceae: *Convolvulus arvensis* L.
Poaceae: *Hordeum murinum* L., *Avena sterilis* L., *Triticum aestivum* L., *Avena sativa* L.

3.1.2.13 *Limothrips denticornis* (Haliday, 1836)
Asteraceae: *Cirsium arvensis* (L.) Scop.
Brassicaceae: *Sinapis arvensis* L.
Fabaceae: *Vicia cracca* L.
Poaceae: *Hordeum vulgare* L., *Triticum aestivum* L.

3.1.2.14 *Odontothrips confusus* Priesner, 1926
Fabaceae: *Coronilla varia* L.

3.1.2.15 *Odontothrips loti* (*Haliday*, 1852)
Asteraceae: *Achillea millefolium* L., *Medicago sativa* L.
Fabaceae: *Coronilla varia* L. *Medicago sativa* L., *Dorycnium herbaceum* Vill.

3.1.2.16 *Oxythrips bicolor* (O.M. Reuter,1879)
Asteraceae: *Helichrysium italicum* (Roth) Mill. corr. Guss., *Inula candida* (L.) Cass, *Inula conyza* DC.
Cichoriaceae: *Scolymus hispanicus* L.
Dipsaceae: *Cephalaria leucantha* (L.) Schrad.
Lamiaceae: *Nepeta cataria* L.
Poaceae: *Zea mays* L.
Rosaceae: *Rubus hirtus* W. et K.
Scrophulariaceae: *Linaria vulgaris* Mill.

3.1.2.17 *Stenothrips graminum* Uzel, 1895
Poaceae: *Triticum aestivum* L.

3.1.2.18 *Sericothrips bicornis* (Karny, 1910)
Fabaceae: *Trifolium repens* L.

3.1.2.19 *Thrips flavus* Schrank, 1776
Asteraceae: *Serratula tinctoria* L., *Helianthus annus* L.

3.1.2.20 *Thrips linarius* Uzel, 1895.
Asteraceae: *Leucanthemum ircutianum* DC
Caprifoliaceae: *Sambucus nigra* L.
Rosaceae: *Rosa canina* L.

3.1.2.21 *Thrips major* Uzel, 1895
Asteraceae: *Leucanthemum ircutianum* DC, *Matricaria chamomilla* L., *Inula helenium* L., *Centaurea cristata* Bartl.,

Centaurea jacea L., *Serratula tinctoria* L., *Cirsium canum* (L.) All.
Boraginaceae: *Lithosperum arvense* L.
Brassicaceae: *Lunaria rediviva* L.
Caryophillaceae: *Lychnis flos-cuculi* L.
Cichoriaceae: *Picris hieracioides* L., *Cichorium intybus* L.
Convolvulaceae: *Convolvulus arvensis* L.
Cucurbitaceae: *Cucumis sativus* L.
Fabaceae: *Trifolium pratense* L., *Phaseolus vulgaris* L.
Liliaceae: *Allium scorodoprasum* L.
Lythraceae: *Lythrum salicaria* L.
Malvaceae: *Malva sylvestris* L.
Poaceae: *Triticum aestivum* L.
Ranunculaceae: *Ranunculus arvensis* L., *Ranunculus acris* L.
Rubiaceae: *Galium mollugo* L., *Galium palustre* L.

3.1.2.22 *Thrips minutissimus* Linnaeus, 1758
Asteraceae: *Leucanthemum ircutianum* DC, *Leucanthenum triviale* (Gaud.) Horvatić
Iridaceae: *Gladiolus gandavensis* van Houtte
Oleaceae: *Olea sativa* (Hoffmg. et Lk.) Fiori

3.1.2.23 *Thrips nigropilosus* Uzel, 1895
Asteraceae: *Acer campestre* L.
Cichoriaceae: *Sonchus arvensis* L., *Teraxacum officinale* Web.

3.1.2.24 *Thrips physapus* Linnaeus, 1758
Asteraceae: *Leucanthemum ircutianum* DC, *Calandula officinalis* L., *Carduus nutans* L., *Centaurea jacea* L. *Centaurea scabiosa* L., *Eupatorium cannabinum* L., *Helianthus annuus* L.
Brassicaceae: *Sinapis arvensis* L., *Sinapis arvensis* L.
Cichoriaceae: *Crepis biennis* L., *Tragopogon pratensis* L.
Cucurbitaceae: *Cucurbita pepo* L.
Papaveraceae: *Papaver rhoeas* L.
Plantaginaceae: *Plantago* sp.
Ranunculaceae: *Ranunculus arvensis* L.
Rosaceae: *Rubus* sp.
Urticaceae: *Urtica dioica* L.

3.1.2.25 *Thrips fuscipennis* Haliday, 1836
Asteraceae: *Leucanthemum triviale* (Gaud.) Horvatić, *Tanacetum vulgare* L.
Brassicaceae: *Brassica napus var. oleifera* DC.
Caprifoliaceae: *Sambucus nigra* L.
Rosaceae: *Rubus idaeus* L., *Rosa* sp.
Saxifragaceae: *Hydrangea hortensis* Sieb.
Solanaceae: *Capsicum annuum* L.

3.1.2.26 *Thrips tabaci* Lindeman, 1888
Apianceae: *Daucus carota* L., *Anethum graveolens* L., *Eryngium amethystinum* L.
Asteraceae: *Achillea millefolium* L., *Leucanthemum ircutianum* DC, *Calystegia sepium* (L.) R.Br. *Centaurea cyanus* L.,, *Matricaria discoidea* DC., *Cirsium arvense* (L.) Scop., *Solidago gigantiea* Ait., *Helianthus annuus* L., *Erigeron annuus* L., C*hrysanthemum* spp., *Solidago irgaurea* L. *Tripleurospermum indorum* (L.) C.H.Schultz., *Inula conyza* DC., *Conyza canadensis* (L.) Cronq, *Artemisia absinthium* L., *Inula crithmoides* L., *Tagetes patulus* L.
Brassicaceae: *Capsella bursa-pastoris* (L.) Med., *Sinapis arvensis* L.
Boraginaceae: *Echium plantagineum* L.
Cactaceae: *Cactus* sp.
Caprifoliaceae: *Sambucus nigra* L., *Sambucus ebulus* L.
Chenopodiaceae: *Beta vulgaris . var. saccharifera* Lange
Cichoriaceae: *Crepis setosa* Hall. f.
Convolvulaceae: *Calystegia sepium* (L.) R.Br
Cucurbitaceae: *Cucurbita pepo* L.
Dipsacaceae: *Cephalaria leucantha* (L.) Schrad.
Fabaceae: *Medicago sativa* L., *Dorycnium herbaceum* Vill., *Spartium junceum Glycine max* (L.) Merr., *Medicago falcata* L., *Lotus corniculatus* L., *Vicia* sp., *Trifolium repens* L., *Genista tinctoria* L., *Melilotus alba* Med.
Iridaceae: *Gladiolus gandavensis* van Houtte
Lamiaceae: *Lavandula latifolis* Med., *Origanum vulgare* L.
Liliaceae: *Allium cepa* L., *Allium* sp.
Malvaceae: *Malva sylvestris* L.
Moraceae: *Ficus carica* L.
Oleaceae: *Olea sativa* (Hoffmg. et Lk.) Fiori
Plantaginaceae: *Plantago altissima* L.
Poaceae *Triticum aestivum* L., *Zea mays* L., *Sorgum bicolor* (L.) Moench., *Sorgum halepense* (L.) Pers.
Polygonaceae: *Rumex crispus* L.
Punicaceae: *Punica granatum* L.
Ranunculaceae: *Nigella arvensis* L.
Resedaceae: *Reseda lutea* L.
Rosaceae: *Filipendula vulgaris* Moench, *Rubus hirtus* W. et K., *Fragaria vesca* L., *Rosa* sp.
Rubiaceae: *Galium verum* L., *Galium mollugo* L.

Rutaceae: *Ruta graveolens* L.
Saxifragaceae: *Hydrangea hortensis* Sieb.
Scropholariaceae: *Verbascum sinuatum* L., *Verbascum sinuatum* L.
Solanaceae: *Lycopersicon esculentum* Mill.

3.1.2.27 *Taeniothrips atratus* (Haliday, 1836)
Caryophllyaceae: *Melandrium album* (Mill.) Garcke.
Geraniaceae: *Pelargonium* spp.
Lamiaceae: *Lavandula latifolia* Med., *Stachys annua* (L.)
Poaceae: *Dactylis glomerata* L
Solanaceae: *Solanum tuberosum* L.

3.1.2.28 *Taeniothrips vulgatissimus* (Haliday, 1836)
Corylaceae: *Corylus avellana* L.

3.1.2.29 *Taeniothrips inconsequens* (Uzel, 1895)
Asteraceae: *Artemisia absinthium* L., *Centaurea diffusa* Lam.
Cichoriaceae: *Picris hieracioides* L.
Lamiaceae: *Stachys palustris* L.
Poaceae: *Lolium perenne* L.
Ranunculaceae: *Clematis flammula* L.

3.1.2.30 Thripidae larvae
Aceraceae: *Acer campestre* L.
Apiaceae: *Daucus carota* L.
Asteraceae: *Leucanthemum triviale* (Gaud.) Horvatić, *Matricaria chamomilla* L., *Inula britannica* L., *Inula helenium* L., *Arctium lappa* L.
Boraginaceae: *Echium vulgare* L.
Brassicaceae: *Raphanus landra* Moretti, *Raphanus raphanistrum* L., *Rorippa sylvestris* (L.) Bess.
Caryophyllaceae: *Lychnis flos-cuculi* L.
Chenopodiaceae: *Beta vulgaris var. saccharifera* Lange
Cichoriaceae: *Taraxacum officinale* Web.
Convolvulaceae: *Convolvulus arvensis* L.
Fabaceae: *Medicago sativa* L. *Melilotus officinalis* (L.) Pall., *Vicia* sp., *Vicia grandiflora* Scop., *Medicago sativa* L., *Glicyne max* (L.) Merr. *Lathyrus tuberosus* L., *Trifolium pratense* L., *Medicago falcata* L., *Lotus corniculatus* L., *Trifolium pratense* L.
Malavaceae: *Malva sylvestris* L.
Oleaceae: *Ligustrum vulgare* L.
Piniaceae: *Pinus* sp.
Poaceae: *Triticum aestivum* L., *Avena sativa* L., *Hordeum vulgare* L., *Zea mays* L., *Sorgum bicolor* (L.) Moench.
Ranunculaceae: *Ranunculus acris* L.
Rosaceae: *Rubus* sp.
Rubiaceae: *Galium mollugo* L.

3.2 Suborder Tubulifera
3.2.1 Family Phlaeothripidae
3.2.1.1 *Bolothrips icarus* (Uzel, 1895)
Caryophyllaceae: *Melandrium album* (Mill.) Garcke
Lamiaceae: *Mentha pulegium* L.
Malvaceae: *Malva sylvestris* L.
Plantaginaceae: *Plantago altissima* L.
Poaceae: *Festuca heterophylla* Lam.
Ranunculaceae: *Clematis flammula* L.

3.2.1.2 *Cryptothrips nigripes* (O. M. Reuter, 188O)
Avagaceae: *Jucca* sp.

3.2.1.3 *Cephalothrips monilicornis* O.M. Reuter 1885
Asteraceae: *Helianthus annuus* L.
Brassicaeae: *Lunaria rediviva* L.
Chenopodiaceae: *Beta vulgaris var. saccharifera* Lange.
Cucurbitaceae: *Cucurbita pepo* L. *Picris* sp.
Dipsacaceae: *Scabiosa* sp.
Fabaceae: *Vicia cracca* L., *Phaseolus vulgaris* L., *Glycine max* (L.) Merr.
Poaceae: *Zea mays* L. *Triticum aestivum* L., *Lolium perenne* L., *Trifolium pratense* L., *Avena sativa* L., *Sorgum halepense* (L.) Pers.
Ranunculaceae: *Ranunculus arvensis* L.
Scrophulariaceae: *Linaria vulgaris* Mill.

3.2.1.4 *Haplothrips aculeatus* (Fabricius, 1803)
Apiaceae: *Daucus carota* L.
Asteraceae: *Cirsium arvensis* (L.) Scop, *Erigeron annuus* L
Cichoriaceae: *Cichorium intybus* L.
Fabaceae: *Phaseolus vulgaris* L., *Medicago sativa* L.
Poaceae: *Zea mays* L., *Triticum aestivum* L., *Avena sativa* L., *Dactylis glomerata* L.

3.2.1.5 *Haplothrips leucanthemi* (Schrank, 1781)
Asteraceae: *Leucanthemum ircutianum* DC, *Matricaria chamomilla* L.
Fabaceae: *Trifolium pratense* L., *Glycine max* (L.) Merr.

3.2.1.6 *Haplothrips minutus* (Uzel, 1895)
Asteraceae: *Erigeron annuus* L., *Tagetes patulus* L., *Solidago gigantea* Ait.
Caryophyllaceae: *Lychnis flos-cuculi* L.
Cichoriaceae: *Cichorium intybus* L.
Cucurbitaceae: *Cucumis sativus* L.
Fabaceae: *Lathyrus tuberosus* L., *Medicago sativa* L., *Trifolium repens* L,

Trifolium pratense L. *Glycine max* (L.) Merr.
Liliaceae: *Lilium* sp., *Allium* sp.
Oleaceae: *Olea sativa* (Hoffmg. et Lk.) Fiori
Pinaceae: *Pinus* sp.
Poaceae: *Zea mays* L., Avena sativa L., *Lolium perenne* L., *Hordeum vulgare* L., *Triticum aestivum* L.
Polygonaceae: *Rumex sanguineus* L.

3.2.1.7 *Haplothrips niger* (Osborn, 1883)
Asteraceae: *Matricaria chamomilla* L.
Caryophyllaceae: *Melandrium album* (Mill.) Garcke
Fabaceae: *Vicia cracca* L.
Plantaginaceae: *Plantago altissima* L.

3.2.1.8 *Haplothrips setiger* Priesner, 1921
Asteraceae: *Matricaria chamomilla* L.
Poaceae: *Triticum aestivum* L.

3.2.1.9 *Haplothrips tritici* Kudjumov, 1912
Asteraceae: *Matricaria chamomilla* L.

3.2.1.10 *Liothrips vaneeckei* Priesner, 1920
Asteraceae: *Helianthus annuus* L.,*Chrysanthemum* spp., *Achillea millefolium* L.
Cichoriaceae: *Sonchum arvensis* L.
Fabaceae: *Trifolium pratense* L., *Trifolium repens* L., *Lathyrus tuberosus* L., *Glycine max* (L.) Merr.
Fagaceae: *Quercus pubescens* Willd.,
Liaceae: *Colchicum autumnale* L.
Onagraceae: *Epilobium hirsutum* L.
Plantaginaceae: *Plantago* sp., *Plantago lanceolata* L.
Poaceae: *Zea mays* L. *Hordeum murinum* L.,. *Triticum aestivum* L., *Avena sativa* L., *Lolium perenne* L., *Sorgum halepense* (L.) Pers.
Rosaceae: *Rubus* sp.
Solanaceae: *Nicotiana tabacum* L.

3.2.1.11 *Neoheergeria verbasci* (Osborn, 1886)
Asteracea: *Centaurea jacea* L.
Brassicaceae: *Capsella bursa-pastoris* (L.) Med.
Polygonaceae: *Rumex obtusifolius* L.
Poaceae: *Avena sativa* L.

3.2.1.12 *Phlaeothrips coriaceus* Haliday, 1836
Poaceae: *Triticum aestivum* L.

3.2.1.13 *Poecilothrips albopictus* Uzel, 1895
Rosaceae: *Malus* sp.

3.2.1.14 *Xylaplothrips fuliginosus* Schille, 1910
Apiaceae: *Daucus carota*. L.
Asteraceae: *Leucanthemum ircutianum* DC, *Matricaria chamomilla* L., *Achillea millefolium* L., *Centaurea cristata* Bartl., *Centaurea jacea* L., *Inula crithmoides* L., *Helichrysium ita*licum (Roth) Mill. corr. Guss, *Tanacetum vulgare* L.
Brassicaceae: *Sinapis arvensis* L.
Caprifilaceae: *Sambucus ebulus* L.
Cichoriaceae: *Crepis biennis* L.
Corylacea: *Carpinus betulus* L.
Dipsacaceae: *Cephalaria leucantha* (L.) Schrad.
Plantaginaceae: *Plantago lanceolata* L.
Solanaceae: *Nicotiana tabacum* L.

3.2.1.15 Phlaeothripidae larvae
Apiaceae: *Daucus carota* L..
Asteraceae: *Triticum aestivum* L., *Matricaria chamomilla* L., *Centaurea cyanus* L., *Achilea millefolium* L., *Inula candida* (L.) Cass.
Dipsacaceae: *Scabiosa* sp.
Fabaceae: *Trifolium repens* L.
Malvaceae: *Malva sylvestris* L.
Plantaginaceae: *Plantago lanceolata* L.
Pintaceae: *Pinus* sp.
Poaceae: *Triticum aestivum* L, *Agropyron pungens* (Pers.) Roem. et Schult, *Zea mays* L. *Avena sativa* L, *Hordeum vulgare* L.

4 DISCUSSION AND CONCLUSIONS

Thrips species determined in the investigation belong to the three families: Aeolothripidae, Thripidae, and Phlaeothripidae. The presence of thrips from those three families was confirmed by Mound et al. (1976.) in most European countries. The host plants of thrips determined in the investigations belongs to 49 botanical families.

Thrips species from Aeolothripidae family were presented on 32 % of botanical families within our research, mostly on families Fabaceae, Asteraceae and Brassicaceae. *Aeolothrips intermedius* – important predator of thrips and mites (Trdan *et al*., 2005), which was found on host plants from 15 different botanical families, was the most abundant species from Aeolothripidae family.

Thrips specimens from Thripidae family were the most abundant; they were from 14 genera and 30 species. They were presented on 89 % of botanical families within our research. Genus *Thrips* with 10 species, and the most abundant species *T. tabaci*, were determined

on 30 botanical families with the highest number on Asteraceae and Fabaceae. The second most abundant thrips species was *Frankliniella intonsa.* This species was presented on 32 % of examined samples, on 29 botanical families, mainly on Asteraceae and Fabaceae, followed by Brassicaceae, Caryophyllaceae, Rosaceae, Lamiaceae, and Ranunculaceae. Both Thysanoptera species are also known as widely distributed insects in Slovenia (Trdan, 2003), Serbia (Andjus and Trdan, 2005ab), Hungary (Jenser and Czencz, 1988) and in many other European countries with continental climate, while only *Thrips tabaci* is known as important pest of some vegetable plants (Trdan *et al*., 2007).

Family Phlaeothripidae was presented with 9 genera and 14 species. Their representatives, which do not belong among important pest species in Croatia, their neighbouring countries and also some Mediterranean countries (Garcia-Fayos and Goldarazena, 2008), were presented on 27 plant families, mainly on Poaceae (40 %), Asteraceae (33 %), and Fabaceae (26 %). The most abundant species from Phlaeothripidae family, which representatives are potential pollinator of their host plants, was *Haplothrips minutus*, which was found in host plants from 10 botanical families.

On the basis of results of present study we can conclude that the majority of Thysanoptera species are polyphagous. This characteristic allow them survival in different agroecosystems, where some of these insects perform the permanent threat to cultivated plants. Therefore the knowledge on host plants of thrips species is highly advantageous in research work as well as in implementation of sustainable methods of thrips control (e.g. trap crops [Buitenhuis *et al*., 2007], intercropps [Trdan *et al*., 2006] etc.) in food production systems.

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6 REFERENCES

Andjus Lj. (1997): Check-list of Thysanoptera in the former Yugoslavia. Acta Entomol. Serb., 2: 117-136.

Andjus, Lj., Trdan, S. (2005a): Duvanov trips (*Thrips tabaci* Lindeman), najštetnina vrsta tripsa na otvorenom prostoru. Biljn. lek., 33: 395-400.

Andjus, Lj., Trdan, S. (2005b): Tripsi na lucerki. Biljn. lek., 33: 538-542.

Buitenhuis, R., Shipp, J. L., Jandricic, S., Murphy, G., Short, M. (2007): Effectiveness of insecticide-treated and non-treated trap plants for the management of *Frankliniella occidentalis* (Thysanoptera: Thripidae) in greenhouse ornamentals. Pest Manag. Sci., 63: 910-917.

Ciglar, I., Medin, A., Bušić, Z., Brekalo, J., Ljubićić, M. (1984): *Taeniothrips meriodinalis* (Priesner.) novi štetnik bresaka u nas. Glas. zašt. bilja, 12: 423-424.

Ciglar, I., Žužić, I. (1990): Lozin trips - *Drepanothrips reuteri* Uzel sve ćešći štetnik u vinogradima. Glas. zaštite bilja, 12: 422–423.

Domac, R. (1994): Flora Hrvatske, priručnik za određivanje bilja. Školska knjiga, Zagreb: 1-504.

Ehrendorfer, F. (1973): List der Gefäßpflanzen Mitteleuropas. Gustav Fischer Verlag, Stuttgart: 1-318.

Garcia-Fayos, P., Goldarazena, A. (2008): The role of thrips in pollination of *Arctostaphyllos uva-ursi*. Int. J. Plant Sci., 169: 776-781.

Janežič, F. (1991): Prispevek k poznanju tripsov ali resarjev (Thysanoptera) na rastlinah v Sloveniji. Zb. Bioteh. Fak. Univ. Ljubl., 57: 169-178.

Janežič, F., Maček, J. (1993): Proširenost kalifornijskog tripsa (*Frankliniella occidentalis* /Perg/) u Sloveniji. Glas. zašt. bilja, 11-12: 310-311.

Jenser, G. (1982): Tripszek – Thysanoptera. Magyarosazág Állatvilága Fauan Hungariae, Akadémiai Kiadó, Budapest: 1-192.

Jenser, G. (1986): Data to the Thysanoptera fauna of the Kiskunsà national park. The Fauna of the Kiskunsàg National Park: 107-111.

Jenser, G., Czencz, K. (1988): Thysanoptera species occurring frequently on cultivated plants in Hungary. Acta Phytopathol. Entomol. Hung., 23: 285-289.

Jenser, G. (1990): Host preference of some Thysanoptera species living in Fabaceae flowers. In: Proceed. 3rd Int. Symp. Thysanoptera, Kazimircz Dolny, Poland: 83-89.

Jenser, G., Balogh, E. (1992): Predatory Thysanoptera in Hungarian Orchards. Növvéd., XXVIII, 9: 352-255.

Jenser, G.. Tusnádi, C. K. (1989): A Nyugati virágtripz (*Frankliniella occidentalis* Pergande) megjelenése Magyarországon. Növvéd., XXV, 9: 389-393.

Jenser, G., Vierbergen, B., Szénási, Á. (2007): Thysanoptera larvae living on chickweed (*Stellaria media* Linnaeus) under continental climatic conditions. Acta Phytopathol. Entomol. Hung., 42: 387-390.

Kovačević, Ž. (1964): Kretanje, brojnost i zastupljenost nekih rodova insekata na lucerištima, djetelištima i livadama. Zašt. bilja 82, XV: 667-685.

Masten, R. (1983): Resičari štetnici plodova breskve. Glas. Zašt. Bilja, 10: 395-396.

Morison, G., Tanasijević, N. (1966): The frequency of Thysanoptera on some crop plants of Yugoslavia. The Entomologist 99: 28-43.

Moritz, G. (1994): Pictorial key to the economically important species of Thysanoptera in Central Europe. Bull. OEPP/EPPO Bull. 24: 181-208.

Mound, A. L., Morison D. G., Pitkin, R.B., Palmer, M. J. (1976): Thysanoptera. Handbook for the Identification of British Insects. Royal Entomological Society of London 1, 11: 8-18.

Mound A. L. (1997): Thrips as crop pests. Biological Diversity. CAB Int.: 198-215.

Okumura, T. G., Papp, S. C. (1991): Insect and Mite Pests in Food. Thrips (Thysanoptera): 403-414.

Raspudić, E. (1996): Fauna tripsa (Insecta: Thysanoptera) u Republici Hrvatskoj. Dr. diss, Fac. Agric. Osijek: 1-139.

Raspudić, E., Ivezić, M. (1999): Biljke domaćini i nalazišta resičara *Thrips tabaci* Lindeman 1888 (Thysanoptera, Thripidae) u Hrvatskoj. Entomologia Croatica 4, 1-2, 57-62.

Raspudić, E., Ivezić, M., Jenser, G. (2003): Check list on Thysanoptera in Croatia. Entomol. Croat., 7: 35-41.

Šimala, M. (1991): *Frankliniella occidentalis* (Perg.) (Thysanoptera, Thripidae) novi štetnik povrća i ukrasnog bilja u Jugoslaviji. Agron. Glas., 4-5: 255-258.

Trdan S. (2002): Vrednotenje morfološke in genetske raznolikosti populacij gospodarsko pomembnih vrst resarjev (Thysanoptera) v Sloveniji. Dokt. dis., Ljubljana, Univ. Ljubl., Bioteh. fak.: 1-90.

Trdan, S. (2003): The occurrence of thrips species from the Terebrantia suborder on cultivated plants in Slovenia. Res. Rep., Biotech. Fac., Univ. Ljubl., Agric. issue 1, 81: 57-64.

Trdan, S., Andjus, Lj., zur Strassen, R. (2003): Chronology of thripsological activities and comparison of check-lists on Thysanoptera in Slovenia and FR Yugoslavia. Acta Entomol. Slov., 11: 61-70.

Trdan, S., Andjus, Lj., Raspudić, E., Kač, M. (2005): Distribution of *Aeolothrips intermedius* Bagnall (Thysanoptera: Aeolothripidae) and its potential prey Thysanoptera species on different cultivated host plants. J. Pest Sci., 78: 217-226.

Trdan, S., Žnidarčič, D., Valič, N., Rozman, L., Vidrih , M. (2006): Intercropping against onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) in onion production: on the suitability of orchard grass, lacy phacelia, and buckwheat as alternatives for white clover. J. Plant Dis. Prot. 113: 24-30.

Trdan, S., Valič, N., Žnidarčič, D. (2007): Field efficacy of deltamethrin in reducing damage caused by *Thrips tabaci* Lindeman on early white cabbage. J. Pest Sci., 80: 217-223.

zur Strassen, R. (1981): Erste daten zur Thysanopteren-fauna des nordwestlichen Istrien (Jugoslawien). Acta entomol. Jugosl., 17: 143-151.

zur Strassen, R. (1984): Zur Thysanopteren-Faunistik des Alpen-Vorlandes von Slowenien, Nebst Einer Check-List der Fransenflügler-Arten von Jugoslawien. Acta entomol. Jugosl. 20: 31-51.

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Agris category code: H10

First massive occurrence of greenhouse whitefly parasitoid, *Encarsia formosa* Gahan (Hymenoptera: Aphelinidae) on greenhouse whitefly, *Trialeurodes vaporariorum* [Westwood] (Homoptera: Aleyrodidae) in Slovenia

Katarina KOS[1], Željko TOMANOVIĆ[2], Helena ROJHT[3], Matej VIDRIH[4], Stanislav TRDAN[5]

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ABSTRACT

In 2008, massive population of parasitoid *Encarsia formosa* was found for the first time in the greenhouses on the Laboratory Field of Biotechnical Faculty in Ljubljana (Slovenia). This species is known for a long time as effective natural enemy of the greenhouse whitefly, *Trialeurodes vaporariorum*, and other whiteflies in different parts of the world. 1306 wasps from genus *Encarsia* were found in nymphs of greenhouse whitefly. The most numerous was *E. formosa* (934 individuals), following by 367 individuals of *E. tricolor*, 4 males of *E. inaron* and a male of *E. longicornis*. Greenhouse whitefly parasitoid was determined on 14 host plants in the greenhouse and *E. tricolor* on 11 host plants in the greenhouse and on one host plant in the field. *E. inaron* and *E. longicornis* appeared only on one host plant in a greenhouse. For the time being the use of wasp *E. formosa* is not yet permitted in controlling greenhouse whitefly in Slovenia, but there is possibility to include it in the programs of biological control of pests on ornamentals and vegetable plants in the greenhouses. Consequently, the use of chemical insecticides will be reduced.

Key words: greenhouse whitefly parasitoid, *Encarsia formosa*, greenhouse whitefly, *Trialeurodes vaporariorum*, biological control, natural enemies, indigenous species, greenhouse, Slovenia

IZVLEČEK

PRVA ŠTEVILČNEJŠA NAJDBA NAJEZDNIKA RASTLINJAKOVEGA ŠČITKARJA, *Encarsia formosa* Gahan **(Hymenoptera: Aphelinidae) NA RASTLINJAKOVEM ŠČITKARJU,** *Trialeurodes vaporariorum* [Westwood] **(Homoptera: Aleyrodidae) V SLOVENIJI**

V rastlinjakih na Laboratorijskem polju Biotehniške fakultete v Ljubljani smo v letu 2008 prvič našli številčnejšo populacijo parazitoida *Encarsia formosa*, ki je v svetu dobro znan naravni sovražnik rastlinjakovega ščitkarja, *Trialeurodes vaporariorum*, in nekaterih drugih vrst ščitkarjev. V ličinkah rastlinjakovega ščitkarja smo našli 1306 osic iz rodu *Encarsia*. Najbolj številčni so bili osebki vrste *E. formosa* (934 osebkov), našli pa smo še 367 osebkov vrste *E. tricolor*, 4 samce vrste *E. inaron* in enega samca vrste *E. longicornis*. Predstavnike vrste *E. formosa* smo našli na 14 gostiteljskih rastlinah v rastlinjakih, vrsto *E. tricolor* pa na 11 vrstah gostiteljskih rastlin v rastlinjakih in na eni rastlinski vrsti na prostem, medtem ko sta se vrsti *E. inaron* in *E. longicornis* pojavili le na eni rastlinski vrsti v rastlinjaku. V Sloveniji uporaba osice *E. formosa* za zatiranje rastlinjakovega ščitkarja še ni razširjena, vendar bi jo lahko vključili v programe biotičnega varstva okrasnih rastlin in vrtnin v zavarovanih prostorih in tako zmanjšali uporabo insekticidov.

Ključne besede: najezdnik rastlinjakovega ščitkarja, *Encarsia formosa*, rastlinjakov ščitkar, *Trialeurodes vaporariorum*, biotično varstvo, naravni sovražniki, domorodna vrsta, rastlinjak, Slovenija

[1] Teach. Assist., B. Sc., Jamnikarjeva 101, SI-1111 Ljubljana; E-mail: katarina.kos@bf.uni-lj.si

[2] Assoc. Prof., Ph. D., University of Belgrade, Faculty of Biology, Studentski trg 16, SER-11000 Belgrade

[3] Teach. Assist., young reseacher, Jamnikarjeva 101, SI-1111 Ljubljana

[4] Teach. Assist., Ph. D., ibid.

[5] Assoc. Prof., Ph. D., ibid,

1 INTRODUCTION

Family of whiteflies (Aleyrodidae) comprises important pests, which attack many cultivated and wild-growing plant species in the open and in the greenhouses. They have incomplete development and adults are around 2 mm in length and have totally white wings, which are covered with waxy coating (Peters, 1993; Succop, 1997). Greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), causes direct damage with sucking sap from the plants, resulting in a yellow mottling on the surface of the leaf, as well as leaf loss, wilting and stunting. Its indirect damage is made by transmission of viruses and producing honeydew, which attract black fungi of sooty molds, *Cladosporium* spp. (Succop, 1997).

Parasitoids from genus *Encarsia* are probably one of the first practically applied biological agents in plant protection. Genus *Encarsia* belongs to subfamily Aphelinidae, family Braconidae and order Hymenoptera. *Encarsia formosa* Gahan is a parasitoid, which is, as biological agent in controlling greenhouse whitefly (Fig.3), spread in different parts of the world (van Lenteren and Woets, 1988; van Lenteren *et al*., 1996). It is used against this pest on vegetable and ornamental plants in greenhouses. Commercial usage of this parasitoid started already around 1920, but after approximately 20 years its interest waned due to intensive development of chemical insecticides. After 1970, interest in greenhouse whitefly parasitoid was reinitiated and its usage in plant protection was expanded in 1993 to 4800 hectares of greenhouse area (van Lenteren and Woets, 1988; van Lenteren, 1995).

Adult wasps of parasitoid (Fig. 1) feed on honeydew and with excreted body fluids of young larvae (L1) of greenhouse whitefly, and doing so they kill them many. If many wasps appear, previously mentioned way of feeding is used also on higher developmental stages of whitefly larvae. To feed host, *Encarsia formosa* wasps wound larvae by probing with the ovipositor and feeds from wounds and that way they are provided with proteins. In this way they kill almost ¾ of whiteflies. Larvae of *Encarsia formosa* feed with the internal content of parasitized whiteflies, eat all the organs and leave only outer armor (Fig. 2) in which they pupate afterward (Milevoj, 2007).

Figure 1*: Adult of Encarsia formosa Gahan (Photo by K. Kos)*

***Figure 2**: Empty pupal cases of greenhouse whitefly on celery (Photo by K. Kos)*

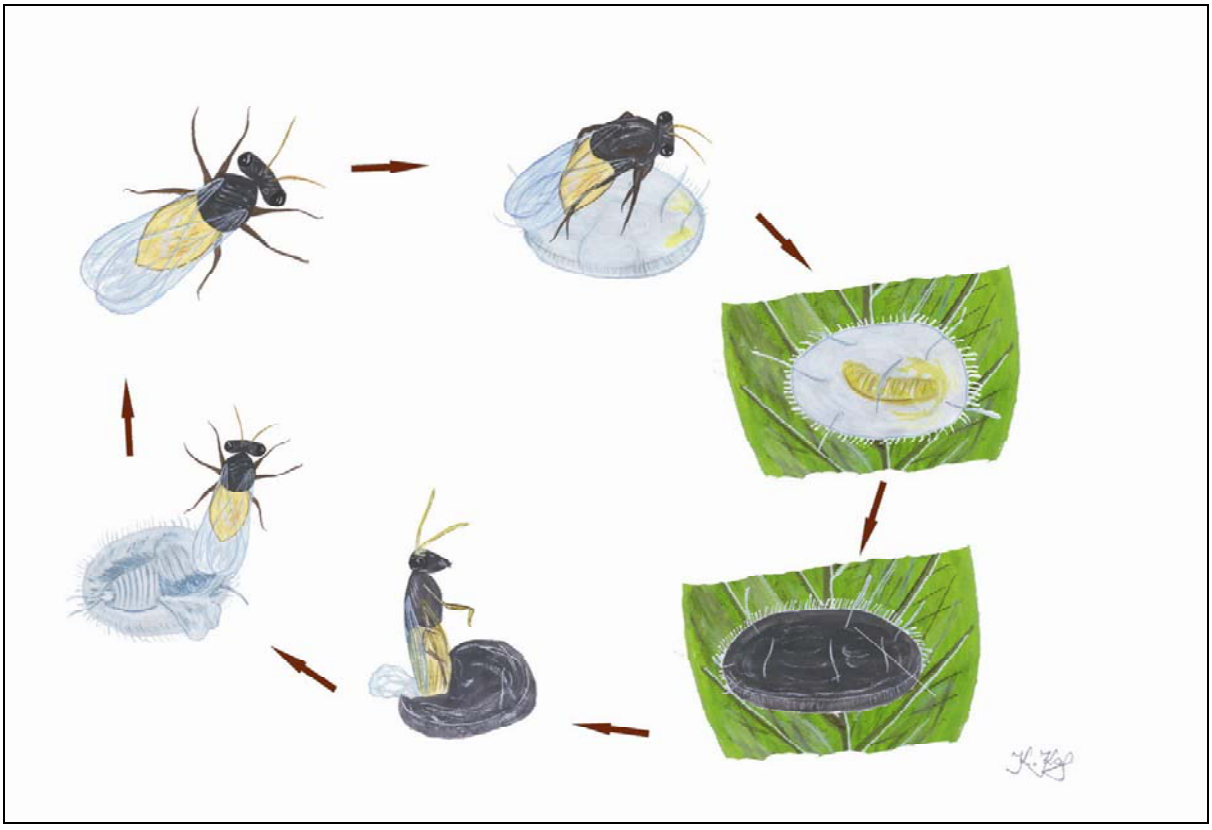

***Figure 3**: Life cycle of Encarsia formosa Gahan on greenhouse whitefly (Photo by K. Kos)*

Encarsia formosa parasitizes at least 15 whitefly species, which belong to 8 genera. The most important hosts of this natural enemy are *Trialeurodes vaporariorum*, *Aleyrodes proletella* (L.), *Bemisia argentifolii* Bellows & Perring and *Bemisia tabaci* (Gennadius) (Schauff and Evans, 1996), but on the other hand greenhouse whitefly parasitoid is also parasitized by three hyperparasitoids: *Signiphora coquilletti* Ashmead (Woolley and Vet, 1981), *Encarsia pergandiella* Howard (Buijs *et al*., 1981) and *Encarsia tricolor* Förster. The later can be also a primary parasitoid, autoparasitoid or hyperparasitoid (Avilla *et al*., 1991).

In August 1994, *Encarsia formosa* was first recorded in Slovenia, namely on tomato plants grown on Laboratory

Field of Biotechnical Faculty in Ljubljana, which were heavily attacked by greenhouse whitefly (Milevoj and Osvald, 1996). But in years which followed, this natural enemy was impossible to find. Target plants which are mentioned by Milevoj and Osvald (1996) as most suitable for introduction of *Encarsia formosa* are pepper, egg plant, bean, cucumber, tomato and rose. It is very important to monitor the first attack of greenhouse whitefly with yellow sticky boards or indicator plants, which are put into the greenhouse with the aim of easier detection of the pest. Among such plant species we can also include fuchsia plants (*Fuchsia* spp.), which have ability of attracting first specimens of whitefly in the greenhouse. The effect of biological control is seen after around 3 weeks. But the strategy of plant protection must be harmonized in a greenhouse. Namely, the wasp is very sensitive to multiple application of fungicides and also foliage fertilizers can do harm to it (Milevoj, 2007).

The aim of our research was to find the indigenous species of natural enemies in greenhouses in Slovenia and in nymphs of greenhouse whitefly from greenhouses on Laboratory Field of Biotechnical Faculty in Ljubljana the high number of greenhouse whitefly parasitoid, *Encarsia formosa* Gahan, and some other *Encarsia* members was found.

2 MATERIAL AND METHODS

At the end of summer 2008 we investigated the presence of parasitoids on greenhouse whitefly, *Trialeurodes vaporariorum*, in a greenhouse on Laboratory Field of Biotechnical Faculty in Ljubljana (46°04' N, 14°31' E). Vegetables, ornamental plants and weeds from the glass and plastic greenhouses were included in a research. One random sample was taken also from the cabbage, attacked by cabbage whitefly, *Aleyrodes proletella* L., grown in the open (village Trstenik near Golnik, 46°20' N, 14°20 E).

The sampling method was adapted to the development of parasitoids inside their hosts. We placed parasitized pupal cases of greenhouse whitefly together with the host plant into the plastic pots, similar as we collected the samples of aphid parasitoids (Brajković and Tomanović, 2005; Kos, 2007; Kos *et al*., 2008). After 3 to 4 weeks we removed dead parasitoids from genus *Encarsia* from the labeled samples. The samples were sent to Natural History Museum in Belgrade (Serbia) for identification (Aleksandar Stojanović).

3 RESULTS WITH DISCUSSION

In the greenhouses on the Laboratory Field of Biotechnical Faculty, the parasitoids of greenhouse whitefly were found in high number. We collected 14 plant species, on which black pupal cases of whiteflies were observed and for which we assumed to be parasitized.

The total number of female wasps had amounted 1306 individuals. *Encarsia formosa* was the most abundant (934 individuals), namely 930 females and 4 males were identified from the samples (Table 1). The second most abundant species was *Encarsia tricolor* Förster with 367 individuals, from which 145 were females and 222 were males. We also found 4 males of *Encarsia inaron* (Walker) and a male of *Encarsia longicornis* Mercet.

Parasitoid *Encarsia formosa* was found on 14 host plants from the greenhouse (Fig. 4) and *Encarsia tricolor* on 11 host plants from the greenhouse and on cabbage in the open. *Encarsia inaron* and *Encarsia longicornis* appeared only on one host plant, i.e. tomato and cherry tomato, respectively, both from the greenhouse. One male and 3 females of *Encarsia tricolor* was collected also from the nymphs of cabbage whitefly, which attacked cabbage (*Brassica oleracea* var. *capitata*) in village Trstenik near Golnik.

***Table 1**: Encarsia species and number of their males and females from greenhouse whitefly, Trialeurodes vaporariorum, collected from 14 different host plants of the pest. The samples were taken from the greenhouses on the Laboratory Field of Biotechnical Faculty in Ljubljana, Slovenia.*

Host plant		Parasitoid			
Common name	Latin name	Species	Number of males	Number of females	**Total**
St John's wort	*Hypericum perforatum* L.	*Encarsia formosa* Gahan	1	112	**113**
		Encarsia tricolor Förster	50		**50**
Common buckwheat	*Fagopyrum esculentum* Moench	*Encarsia formosa* Gahan		45	**45**
Tomato	*Lycopersicon esculentum* Mill.	*Encarsia formosa* Gahan		208	**208**
		Encarsia tricolor Förster	51	35	**86**
		Encarsia inaron (Walker)	4		**4**
Basil	*Ocimum polystachion* L.	*Encarsia formosa* Gahan		62	**62**
		Encarsia tricolor Förster	1		**1**
Common chicory	*Cichorium intybus* L.	*Encarsia formosa* Gahan		105	**105**
		Encarsia tricolor Förster	2		**2**
Celery	*Apium graveolens* L.	*Encarsia formosa* Gahan		10	**10**
Cherry tomato	*Lycopersicon esculentum* Mill.	*Encarsia formosa* Gahan		23	**23**
		Encarsia tricolor Förster	1	19	**20**
		Encarsia longicornis Mercet	1		**1**
Fuchsia	*Fuchsia* spp.	*Encarsia formosa* Gahan		85	**85**
Bean	*Phaseolus vulgaris* L.	*Encarsia formosa* Gahan	3	187	**190**
		Encarsia tricolor Förster	38		**38**
Asparagus	*Asparagus officinalis* L.	*Encarsia formosa* Gahan		6	**6**
		Encarsia tricolor Förster	2		**2**
Marjoram	*Majorana hortensis* Moench	*Encarsia formosa* Gahan		8	**8**
		Encarsia tricolor Förster	26		**26**
Holy basil	*Ocimum sanctum* L.	*Encarsia formosa* Gahan		70	**70**
		Encarsia tricolor Förster	18	4	**22**
Cucumber	*Cucumis sativa* L.	*Encarsia formosa* Gahan		1	**1**
		Encarsia tricolor Förster	13	11	**24**
Pepper	*Capsicum annuum* L.	*Encarsia formosa* Gahan		8	**8**
		Encarsia tricolor Förster	20	76	**96**

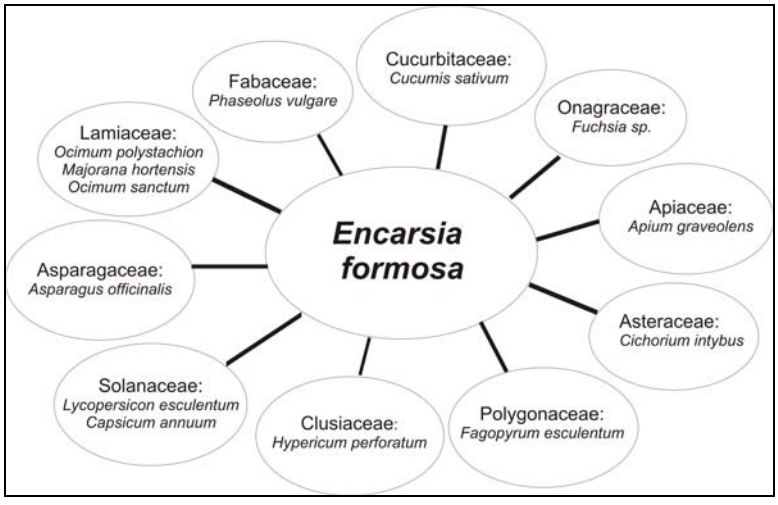

***Figure 4**: Host plants of greenhouse whitefly, Trialeurodes vaporariorum, from the greenhouses, in which greenhouse whitefly parasitoid, Encarsia formosa, was found.*

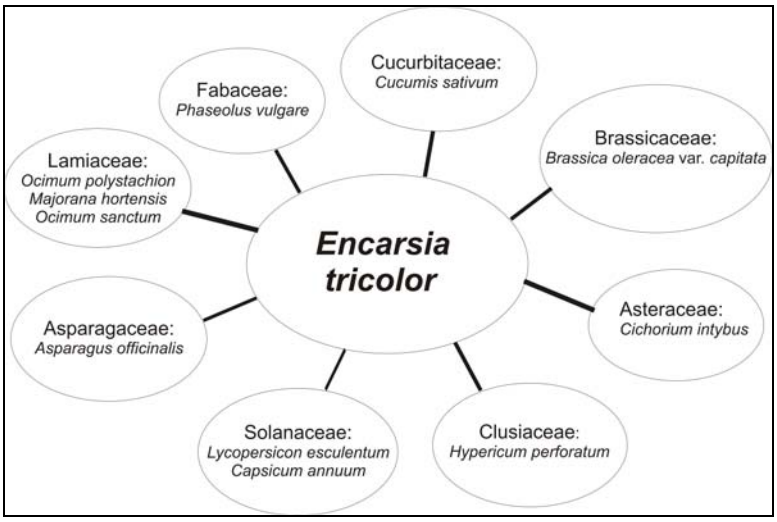

***Figure 5**: Host plants of greenhouse whitefly, Trialeurodes vaporariorum, from the greenhouses, in which Encarsia tricolor was found. The same parasitoid was recored also on cabbage, attacked by cabbage whitefly, Aleyrodes proletella.*

4 CONCLUSIONS

In 2008, high number of parasitoid wasps from genus *Encarsia* was found on vegetables and ornamental plants in greenhouses on Laboratory Field of Biotechnical Faculty in Ljubljana. *Encarsia formosa*, which is considered to be one of the most important biological agent in controlling whiteflies in greenhouses (Hoddle, 1997), was the most abundant *Encarsia* species in our research. Most often it is used in controlling greenhouse whitefly, *Trialeurodes vaporariorum,* and tobacco whitefly, *Bemisia tabaci* (Hoddle *et al*., 1998).

Entire number of wasps, we found, was 1308, from which 934 individuals belonged to the species *Encarsia formosa* (930 females and 4 males) and 367 individuals were identified as *Encarsia tricolor* (145 females and 222 males). We also recorded 4 males of *Encarsia inaron* and a male of *Encarsia longicornis*. We ascertained *Encarsia formosa* on 14 different host plants in greenhouse and *Encarsia tricolor* on 11 host plants in greenhouse and on cabbage, which was grown outdoor in village Trstenik in Gorenjska region.

Greenhouse whitefly represents large problems in growing vegetables and ornamental plants in greenhouses in Slovenia. For this reason the use of *Encarsia formosa* in a frame of integrated plant protection against the pest mentioned could be practiced as an important measure in reducing damage. Introduction of parasitoid *E. formosa* is relatively simple and this biological control agent can effectively reduce the population of whitefly. Use of *E. formosa* is a good example of reduction of damage, caused by greenhouse whitefly, and at the same time there is no need for relying solely on insecticides (Succop, 1997).

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6 REFERENCES

Avilla J., Anandon J., Sarasua M.J., Albajes, R. 1991. Egg allocation of the autoparasitoid *Encarsia tricolor* at different relative densities of the primary host (*Trialeurodes vaporariorum*) and two secondary hosts (*Encarsia formosa* and *E. tricolor*). Entomol. Exp. Appl. 59: 219–27.

Brajković, M., Tomanović, Ž. 2005. Entomološki praktikum. Metode sakupljanja, preparovanja insekata. Beogr., Biol. fak., Univ. Beogr.: 106 p.

Buijs, M.J., Pirovano, I., van Lenteren, J.C. 1981. *Encarsia pergandiella*, a possible biological control agent for the greenhouse whitefly, *Trialeurodes vaporariorum*. A study on intra and interspecific host selection. Med. Fac. Landbouww. Rijksuniv. Gent 46: 465–75.

Hoddle M. S. 1997. *Encarsia formosa* (Hymenoptera: Aphelinidae). In: Weeden, C. (ur.): Biological control: a guide to natural enemies in North America, Cornell University. Infoseek http://www.nysaes.cornell.edu/ent/biocontrol/parasitoids/eformosa.html (30.1. 2009).

Hoddle, M. S., VanDriesche, R. G., Sanderson, J. P. 1998. Biology and use of the whitefly parasitoid *Encarsia formosa*. Annu. Rev. Entomol. 43: 645-669.

Kos, K. 2007. Aphids (Aphididae) and their parasitoids in a vegetable ecosystem. Grad. Th.,, Univ. Ljubl., Biotech. Fac., Dept. Agronomy: 69 p. [Slovenian].

Kos, K., Tomanović, Ž., Petrović-Obradović, O., Laznik, Ž., Vidrih, M., Trdan S. 2008. Aphids (Aphididae) and their parasitoids in selected vegetable ecosystems in Slovenia. Acta Agric. Slov., 91: 15-22.

Milevoj, L., Osvald, J. 1996. Methods for integrated culitvation and control of horticultural crops. Proceed. Symp. New challenges in field crop production. Ljubl., Biotech. Fac., Dept. Agron.: 313-317 [Slovenian].

Milevoj, L. 2007. Biological control of pests in greenhouses. Univ. Ljubl., Biotech. Fac., Dept. Agron.: 51 p. [Slovenian].

Peters, T. M. 1993. Insects and human society. Univ. Mass.: 450 p.

Succop, B. 1997. The parasitism of greenhouse whitefly, *Trialeurodes vaporariorum*, by the parasitic wasp, *Encarsia formosa*: a biological control method in greenhouses. Insect Behavior Review Articles 1997.

http://www.colostate.edu/Depts/Entomology/courses/en507/papers_1997/succop.html. (30.1.2009)

van Lenteren, J. C., van Roermund, H. J. W., Sutterlin S. 1996. Biological control of greenhouse whitefly (*Trialeurodes vaporariorum*) with the parasitoid *Encarsia formosa*: How does it work? Biol. Control 6: 1-10.

van Lenteren, J. C., Woets, J. 1988. Biological and integrated control in greenhouses. Annu. Rev. Entomol. 33: 239–69.

van Lenteren J. C. 1995. Integrated pest management in protected crops. In: Dent, D. R. (ed.). Integrated Pest Management: Principles and Systems Development. London, Chapman & Hall. 311–343.

Woolley, J. B.,Vet, L. E. M. 1981. Postovipositional web-spinning behavior in a hyperparasite *Signiphora coquelletti* Ashmead (Hymenoptera: Signiphoridae). Neth. J. Zool. 31: 627-633.

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Agrovoc descriptors: *Steinernema feltiae*; *Melolontha melolontha*; biological control; temperature; pest control; mortality; plant protection

Agris category code: H10

Efficacy of two strains of *Steinernema feltiae* (Filipjev) (Rhabditida: Steinernematidae) against third-stage larvae of common cockchafer (*Melolontha melolontha* [L.], Coleoptera, Scarabaeidae) under laboratory conditions

Žiga LAZNIK[1], Tímea TÓTH[2], Tamás LAKATOS[3], Matej VIDRIH[4], Stanislav TRDAN[5]

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ABSTRACT

In a laboratory experiment an efficacy of entomopathogenic nematode *Steinernema feltiae* in controlling third-stage larvae of common cockchafer (*Melolontha melolontha*) was studied. The experiment comprised of commercial product Entonem and indigenous strain C76. The efficacy of both biological agents was tested at 20 and 25 ºC and at four different concentrations of nematode suspension: 0, 250.000 infective juveniles [IJs]/m^2, 500.000 IJs/m^2, and 1.000.000 IJs/m^2. Higher mortality rate (27 %) of white grubs was obtained for strain C76 rather than for commercial product (20 %). In our experiment temperature proved to be the most limiting factor in efficacy of tested biological agents. Meanwhile, mortality rate at 20 ºC was 34 % and only 12 % mortality was achieved at 25 ºC. At highest concentration of nematode suspension and 20 ºC also the highest mortality rate (53 %) with strain C76 was obtained.

Key words: *Steinernema feltiae*, *Melolontha melolontha,* biological control, temperature, concentration of nematode suspension

IZVLEČEK

LABORATORIJSKO PREUČEVANJE UČINKOVITOSTI DVEH RAS ENTOMOPATOGENE OGORČICE *Steinernema feltiae* (Filipjev) **(Rhabditida: Steinernematidae) ZA ZATIRANJE LIČINK TRETJE LARVALNE STOPNJE POLJSKEGA MAJSKEGA HROŠČA** (*Melolontha melolontha* [L.], **Coleoptera, Scarabaeidae)**

V laboratorijskem poskusu smo preučevali učinkovitost entomopatogene ogorčice *Steinernema feltiae* za zatiranje ličink tretje larvalne stopnje poljskega majskega hrošča (*Melolontha melolontha*). V poskus smo vključili komercialni pripravek Entonem in domorodno raso C76. Delovanje omenjenih biotičnih agensov smo ugotavljali pri 20 in 25 ºC ter štirih različnih koncentracijah suspenzije ogorčic: 0, 250.000 infektivnih ličink [IL]/m^2, 500.000 IL/m^2 in 1.000.000 IL/m^2. Rasa C76 je vplivala na višjo stopnjo smrtnosti (27 %) ogrcev, v primerjavi s komercialnim pripravkom (20 %). Temperatura se je v našem poskusu izkazala kot najbolj omejujoč dejavnik učinkovitosti preizkušanih biotičnih agensov, saj smo pri 20 ºC dosegli 34 % smrtnost ogrcev, medtem ko je bila ta pri 25 ºC le 12 %. Pri najvišji koncentraciji suspenzije ogorčic in 20 ºC je bila pri rasi C76 dosežena najvišja stopnja smrtnosti ogrcev, in sicer 53 %.

Ključne besede: *Steinernema feltiae*, *Melolontha melolontha*, biotično varstvo rastlin, temperatura, koncentracija suspenzije ogorčic

[1] Young researcher, B. Sc., Jamnikarjeva 101, SI-1111 Ljubljana, email: ziga.laznik@bf.uni-lj.si

[2] Ph.D student, M. Sc., Vadastag 2, H-4244 Újfehértó, Hungary

[3] Ph. D, Vadastag 2, H-4244 Újfehértó, Hungary

[4] Teach. Assist., Ph. D, Jamnikarjeva 101, SI-1111 Ljubljana

[5] Assoc. Prof., Ph. D, Jamnikarjeva 101, SI-1111 Ljubljana

1 INTRODUCTION

Several members of beetles from the family Scarabaeidae, *Phyllophaga* spp. Harris, *Rhizotrogus majalis* (Razoumowsky), *Popillia japonica* Newman and *Melolontha melolontha* (L.), are important pests of grass sward and ornamental plants in Europe and North America (Simard *et al*., 2001). Adult beetles feed with leaves and flowers of fruit and forest trees and of ornamental plants, meanwhile larvae – white grubs - are soil pests and they feed on belowground parts of the plants (Keller and Zimmermann, 2005). In Slovenia, common cockchafer (*Melolontha melolontha* [L.]) is one of the most economically important pests of grasslands. It has a three year developmental cycle with different succession in its time and place of appearance (Vrabl, 1992). In a period from 2001 to 2007 we witnessed the massive occurrence of previously mentioned pest in the area of Črni vrh plateau (Northwest part of Slovenia) and which caused in time frames from 2002 to 2003 and 2005 to 2006 a grass sward devastation on 760 ha or on the area of 62 % of all agricultural land from that region (Poženel, 2007). The population of white grubs in abovementioned years extended to more than 200 larvae/m^2 (Poženel, 2007).

Control of common cockchafer is feasible with the application of insecticides. However, due to the appearance of insect resistance, efficacy decrease owing to soil microorganisms activity and doubts on environmentally acceptability of such kind of products, alternative solution are sought for its control (Koppenhöfer and Kaya, 1998). In controlling white grubs of common cockchafer with biological control measures most frequently the application of entomopathogenic fungus *Beauveria brongniartii* (Sacc.) Petch (Ascomycota: Hypocreales) (Keller and Brenner, 2005) is used. Main characteristic of the members of this phylum is a formation of mycelium, which carries asexual spores (conidia) on special conidiogenous cells. Conidia of majority of entomopathogenic fungus from order Hypocreales firmly fasten to insect cuticle. Host death takes place due to the suspension of nutrients transport, physical barriers and toxic extracts, as beauvericin is (Boucias *et al*., 1994).

Entomopathogenic nematodes (EPNs) from families Steinernematidae and Heterorhabditidae are important natural enemies of insects (Kaya, 1990). They are soil organisms, which live in mutualistic relationship with bacteria from the genera *Xenorhabdus* and *Photorhabdus* (Burnell and Stock, 2000). Once inside the infected insect, symbiotic bacteria are released from the bodies of infective juveniles (third larval stage of EPNs) to the host hemocoel system. And with the excretion of several toxins they cause its death in 24 to 72 hours (Forst and Clarke, 2002).

In Slovenia EPNs were till recently known as exotic species, which usage was possible only in laboratory experiments (Trdan *et al*., 2006, 2008). Since 2006 we actively examine EPNs fauna in Slovenian soils and up till now we confirmed the presence of 5 species: *Steinernema feltiae* (Filipjev) (strains B30, B49, C76), *Steinernema carpocapsae* (Weiser) (strains C67, C101, C110, C119), *Steinernema kraussei* (Steiner) (strains C46, C49), *Steinernema affine* (Bovien) (strain A12) and *Heterorhabditis bacteriophora* (Poinar) (strain D54) (Laznik *et al*., 2008ab). Strain which was used in our experiment, *S. feltiae* C76, was isolated in central part of Slovenia (Logatec area). In addition to this strain we included in a laboratory experiment for controlling common cockchafer also commercial product Entonem (Koppert B. V. Berkel en Rodenrijs, The Netherlands), which active ingredient is also *S. feltiae*.

The aims of our research was to study the efficacy of indigenous strain, *S. feltiae* C76, in a comparison to commercial product Entonem when controlling third stage-larvae of common cockchafer, and on the other hand to determine the influence of temperature and concentration of suspension on the activity of studied biological agents.

2 MATERIALS AND METHODS

2.1 Common cockchafer and entomopathogenic nematodes

In an experiment, which was conducted in an Entomological Laboratory of Chair of Phytomedicine, Agricultural Engineering, Crop Production, Pasture and Grassland Management (Agronomy Department at Biotechnical Faculty in Ljubljana, Slovenia), we studied the efficacy of EPNs in controlling third stage-larvae of common cockchafer. We collected white grubs (500) in the area of Črni Vrh above Idrija (45°55'27'' N, 14°2'37'' E, altitude 710 m) with the use of soil excavations.

We included indigenous strain of *Steinernema feltiae*, C76, which was isolated from the soil in the area of Logatec (45°54'52'' N, 14°13'33'' E, altitude 470 m) (Laznik *et al*., 2009). Strain *S. feltiae* C76 was reared using late instar larvae of *Galleria mellonella* (L.) (Bedding and Akhurst, 1975). We used only infective juveniles which were less than 2 weeks old. During the experiment, which was repeated three times, we stored the infective juveniles at 4 ºC. Product Entonem

(Koppert B.V., Berkel en Rodenrijs, The Netherlands) was supplied by the importer Zeleni hit d.o.o. (Ljubljana, Slovenia).

2.2 Laboratory bioassay

We tested the efficacy of the EPNs in controlling third larval stage of the common cockchafer by exposing individuals to either 0, 250.000 IJs/m^2, 500.000 IJs/m^2 or 1.000.000 IJs/m^2. We determined the number of infective juveniles in a previously prepared unknown concentration of nematode suspension by counting the number of such in droplets (5 µl x 5) and by diluting (adding M9 solution) or by concentrating (reduction to an adequate volume with the assistance of centrifugation) (Laznik *et al*., unpubl.). In this manner we obtained the selected concentrations of nematode suspensions (0, 750, 1.500 and 3.000 IJs/ml).

Precedently (2 weeks before inserting larvae into a place) we put in an experimental vessel (10 x 15 x 10 cm = l x w x d) 300 g of soil and 50 grains of wheat. With this we wanted to ensure enough roots which would serve as additional food for white grubs during the experiment. To each plastic vessel we then add 5 third-stage larvae of common cockchafer. Chosen concentration we applied in a 5 ml dose. Afterwards we moistured soil additionally with ordinary water (sprayer employment). Each treatment was repeated for five times. Experimental vessels were put in a rearing chamber (type: RK-900 CH, producer: Kambič Laboratory equipment, Semič, Slovenia) with a volume of 0.868 m^3 (width x height x depth = 1000 x 1400 x 620 mm). We tested the efficacy at two different temperatures (20 and 25 ºC) and at a relative humidity of 80 %. The number of dead larvae of *M. melolontha* was determined 3, 7, and 10 days after treatment. We moistured soil daily and added supplementary feed for white grubs (carrot). The dead individuals were dissected to determine if the nematodes were present. In such a manner we wanted to prove that the insects died due to the EPNs' activity.

2.3 Statistical analysis

A multifactor analysis of variance (ANOVA) was conducted to determine the differences in mortality rates (%) between the larvae of *M. melolontha* reared in 16 different treatments (two strains of *S. feltiae* – each with four different concentrations at two different temperatures). Before the analysis, the mean mortality was tested for the homogeneity of treatment variances. The mortality data were corrected according to Abbott's formula (Abbott, 1925) and normalized using the arcsine square-root transformation. Duncan's multiple range test ($P \leq 0.05$) was used to separate mean differences among the parameters in all the treatments. All statistical analyses were performed with Statgraphics Plus for Windows 4.0 (Manugistics, Rockville, MD, USA) and the figure was created with MS Office Excel 2003. The data are presented as untransformed means ± SE.

3 RESULTS

3.1 Analysis of pooled results

Analysis of pooled results showed that larval mortality of common cockchafer was significantly influenced by the concentration of nematode suspension (F=6.88; df=2, 179; P<0.0070), temperature (F=499.91; df=1, 179; P<0.0001), nematode strain (F=59.11; df=1, 179; P<0.0001) and day after treatment (DAT) (F=5.41; df=2, 179; P<0.0161), interaction between DAT and concentration of nematode suspension (F=3.63; df=4, 179; P<0.0275), interaction between concentration of nematode suspension and nematode strain (F=64.01; df=2, 179; P<0.0001), interaction between concentration of nematode suspension and temperature F=29.39; df=2, 179; P<0.0001), interaction between nematode strain and temperature (F=251.58; df=1, 179; P<0.0001) and interaction between concentration of nematode suspension, nematode strain and temperature (F=49.94; df=2, 179; P<0.0001). Interaction between DAT and nematode strain (F=0.75; df=2, 179; P<0.4903), interaction between DAT and temperature (F=1.22; df=2, 179; P<0.3225), interaction between DAT, concentration of nematode suspension and nematode strain (F=1.46; df=4, 179; P<0.2596), interaction between DAT, concentration of nematode suspension and temperature (F=0.37; df=4, 179; P<0.8265) and interaction between DAT, nematode strain and temperature (F=0.62; df=2, 179; P<0.5511) did not have significant influence on the larval mortality rate of common cockchafer. In all treatments total mortality was significantly different from the control treatment. Corrected mortality was therefore calculated.

We found significant differences between both strains of EPNs and between both temperature values. Mortality of white grubs which were exposed to strain C76 was 26.73±2.60 %, meanwhile mortality of white grubs exposed to product Entonem was 19.64±2.15 %. Average white grubs mortality at 20 ºC was 33.49±2.49 % and at 25 ºC was 12.88±1.75 %. Concentration of nematode suspension had no influence on mortality of common cockchafer white grubs, while no statistically significant differences between individual levels of this factor (750, 1.500, and 3.000 IJ/ml) have been found (20.96±2.74, 23.48±2.96 and 25.12±3.17 %). Significant differences have not been determined between days after treatment (DAT) as an average white grubs mortality for the 3rd, 7th and 10th day was 21.11±2.87, 23.77±2.99 and 24.68±3.02 %.

Table 1: *Mean mortality (± SE) of third-stage larvae of Melolontha melolontha treated with three different concentrations of two strains of Steinernema feltiae at 20, and 25 ºC 10 DAT. The data shown are corrected for control mortality.*

Temperature (ºC)	*S. feltiae* strain	Nematode concentration (IJs/ml) 750	1500	3000
20	C76	34.57 ± 3.98	45.80 ± 4.35	52.67 ± 6.28
	Entonem	27.13 ± 6.07	30.82 ± 5.71	9.96 ± 3.74
25	C76	0.00 ± 0.00	12.90 ± 4.01	14.46 ± 3.79
	Entonem	22.15 ± 5.13	4.42 ± 2.55	23.38 ± 4.79

3.2 Individual analysis

At 20 ºC and 10 DAT, when strain C76 was applied at middle and high concentration of nematode suspension, it performed significanlty better as product Entonem (Table 1). At lowest concentration of nematode suspension (750 IJs/ml) we did not determine any significant differences between both strains when controlling white grubs. Their mortality when treated with strain C76 was 34.57 ± 3.98 % and mortality of those treated with commercial product Entonem was 27.13 ± 6.07 %.

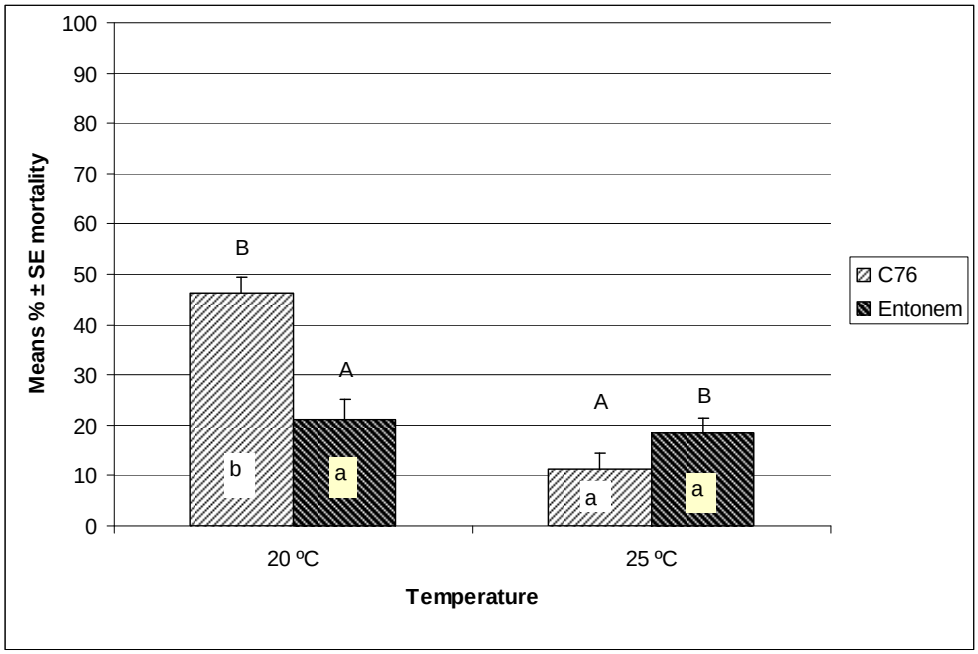

Fig. 1: *Mean mortality (± SE) of third-stage larvae of Melolontha melolontha treated with two different strains of Steinernema feltiae depending on rearing temperature at all three different concentrations 10 DAT. The data shown are corrected for control mortality and analyzed by multifactor ANOVA. Capital and lower-case letters correspond to the grouping of means by Duncan's multiple range test (P≤0.05) for EPN strains and temperature, respectively. The same letters do not differ significantly.*

At 1.500 IJs/ml concentration of nematode suspension white grubs mortality which were exposed to strain C76 was 80 ± 4.35 % and significantly smaller (30.82 ± 5.71 %) was observed when white grubs were treated with commercial product. Commercial product Entonem was the least effective (9.96 ± 3.74 %) at highest concentration of nematode suspension (3000 IJ/ml), meanwhile the strain C76 was the most effective (52.67 ± 6.28 %).

Activity of both studied strains was significantly poorer at 25 ºC than at 20 ºC (Figure 1). Commercial product was the most efficient at highest and lowest concentration of nematode suspension (23.38 ± 4.79;

22.15 ± 5.13 %), meanwhile the activity of indigenous strain C76 was at that temperature considerable poorer (from 0.0 ± 0.0 % at 750 IJs/ml to 14.46 ± 3.79 % at 3000 IJs/ml).

4 DISCUSSION

Results of our research demonstrated that indigenous strain *S. feltiae* C76 attained higher mortality rate (27 %) of third-stage larvae of common cockchafer than commercial product Entonem (20 %). In a similar research, Berner and Schnetter (2001) reported on 3 % larval mortality when *S. feltiae* strain Ehlers was applied and that as the best nematode in their experiment proved to be *S. glaseri* strain RS92 (60 %). Reason for poorer activity of *S. feltiae* we can attribute to the fact, that it goes for the species which has not been found in naturaly infected white grubs as this is documented for *S. anomali* (Kozodoi) *S. glaseri* (Steiner), *S. kushidai* (Mamiya), *S. scarabaei* (Stock), and *Heterorhabditis megidis* (Poinar) (Poinar, 1975).

Georgis and Gaugler (1991) argumented the ineffectiveness of entomopathogenic nematodes in controlling beetles from the family Scarabaeidae in most situations to unsuitable selection of strains, temperature and life cycle of insect. Several researches demonstrated that most effective strains which controlled white grubs were *H. bacteriophora* GPS11 (83-96 %), *H. zealandica* X1 (96-98 %) and *S. scarabaei* (100 %) (Cappaert and Koppenhöfer, 2003; Koppenhöfer and Fuzy, 2003; Grewal *et al*., 2004).

Constrast between strains studied in our experiment can be found due to the fact that strain C76 is much bettter adapted to the larvae of common cockchafer as we confirmed its finding in the area (Laznik *et al*., 2009), where in the past common cockchafer caused quite an extensive damage on grasslands (Urek in Milevoj, 1993). Grewal *et al*. (2004) came to similar conclusions, namely that different strains of the same EPN species might act differently on various insect pests. It was established multiple times that indigenous strains are more virulent from the exotic strains, in spite of the fact that Grewal *et al*. (2004) did not manage to confirm this in their research when studying *Popillia japonica* Newman and *Cyclocephala borealis* Arrow.

Developmental stage of insect pest influences the activity of EPNs (Georgis and Gaugler, 1991). When controlling the youngest larvae (L1) of common cockchafer with the nematode *H. downesi* strain 267 Lakatos and Tóth (2006) established 90 % efficacy at 20 ºC. When comparing L3 and L2 stages they gained higher mortality at latter one when controlling *Anomala orientalis* (Waterh.) (Lee *et al*., 2002). In a similar study, when controlling common cockchafer with the nematodes *S. glaseri* and *Heterorhabditis* sp., the most susceptible were the larval stages L1 and L2 (Deseö *et al*., 1990).

In our experiment concentration of nematode suspension had no influence on mortality of third-stage larvae of common cockchafer. In related experiments concentration of nematode suspension varied between 0.5 and 12.5 x 10^9 IJs/ha. To somehow similar results, that concentration of nematode suspension has no significant effect on mortality of exposed insects (*P. japonica*, *A. orientalis* and *Rhizotrogus majalis* [Razoumowsky]) came also Grewal *et al*. (2004), who attained similar mortality rate at 2.5 and 5.0 x 10^9 IJs/ha. Application of nematode suspension in concentration above 2.5 x 10^9 IJs/ha is not economicaly justified (Grewal and Georgis, 1998). From this view, the choice of suitable species, that is nematode species which showed superior efficacy in controlling larvae of common cockchafer in the previous experiments (e.g. *S. scarabaei*), would be the best solution.

Temperature demonstrated in our experiment as the most limiting factor which influences the activity of EPNs. At 20 ºC we attained 34 % mortality of L3 larval stage, meanwhile only 12 % mortality was found at 25 ºC. We came to likewise findings also at some other researches (Trdan *et al.*, 2006, 2008; Laznik *et al*., 2009), where we also concluded that mortality of studied insects is influenced at most by the temperature. Grewal *et al*. (2004) reports that different species of EPNs have different optimal temperatures to control pest insects. Simões *et al*. (1993) reported about nematodes *S. glaseri* and *H. bacteriophora*, which caused at 23 ºC 100 % larvae mortality of beetle *P. japonica*; meanwhile *S. carpocapsae* gained at the same conditions only 56 % mortality and at lower than 15 ºC only *S. glaseri* preserved satisfying efficacy rate.

In our experiment, the most promising activity demonstrated the strain C67 at 20 ºC and at highest concentration of nematode suspension (53 %), meanwhile the highest effect of bioproduct Entonem was attained at 20 ºC and at middle concentration of nematode suspension (31 %). At corresponding application *S. feltiae* can very satisfying control the younger larval stages of common cockchafer, but when compared to entomopathogenic fungus *Beuveria brongniartii* (Poženel, 2007), the efficacy of the nematodes is lower. Results of some researches indicate positive interaction in simultaneous application of entomopathogenic nematodes and entomopathogenic fungus (Shapiro-Ilan *et al*., 2004), but more detailed

mechanisms of their common functioning are for now poorly studied. It is well known that some species of EPNs (*S. carpocapsae* in *H. indica*) in relation to entomopathogenic fungus act antagonistically, meanwhile *H. bacteriophora* act additively (Shapiro-Ilan *et al*., 2004). Interaction between entomopathogenic fungi and entomopathogenic nematodes depends at a larger scale also from the target pest (Barbercheck and Kaya, 1991). In future researches we want to study additivity on usage of *S. feltiae* strain C76 and indigenous strain of entomopathogenic fungus *B. brongniartii* in controlling larvae of common cockchafer.

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6 REFERENCES

Abbott W. S. 1925. A method of computing the effectiveness of an insecticide. J. Econ. Entomol. 18: 265-267.

Barbercheck, M.E., Kaya, H.K. 1991. Competitive interactions between entomopathogenic nematodes and *Beauveria bassiana* (Deuteromycotina: Hyphomycetes) in soilborne larvae of *Spodoptera exigua* (Lepidoptera: Noctuidae). Environ. Entomol. 20: 707-712.

Berner, M., Schnetter, W. 2001. Wirksamkeit entomopathogener Nematodes gegen Engerlinge der Maikäfer *Melolontha melolontha* und *M. hippocastani*. Mitt. Dtsch. Ges. Allg. angew. Entomol. 13: 165-167.

Boucias, D.G., S.Y. Hung, I. Mazet, and J. Azbell. 1994. Effect of the fungal pathogen *Beauveria bassiana*, on the lysozyme activity in *Spodoptera exigua* larvae. Experientia. 50: 142-147.

Burnell A.M., Stock S.P. 2000. *Heterorhabditis*, *Steinernema* and their bacterial symbionts – lethal pathogens of insects. Nematology 2: 31-42.

Cappaert, D.C., Koppenhöfer, A.M. 2003. *Steinernema scarabaei*, an entomopathogenic nematode for control of the European chafer. Biol. Control 28: 379-386.

Deseö, K.V., Bartocci, R., Tartaglia, A., Rovesti, L. 1990. Entomopathogeneous nematodes for control of scarab larvae. IOBC/wprs Bull. 14: 57-58.

Forst S., Clarke D. 2002. Bacteria-nematode symbiosis. In: Gaugler R (ed) Entomopathogenic Nematology. CABI Publ., Wallingford: 57-77.

Georgis, R., Gaugler, R. 1991. Predictability in biological control using entomopathogenic nematodes. J. Econ. Entomol. 84: 713-720.

Grewal, P.S., Georgis, R. 1998. Entomopathogenic nematodes. In: Hall, F.R. and Menn, J.J. (eds) Biopesticides: Use and Delivery. Humana Press, Totowa, New Jersey: 271-299.

Grewal, P.S., Power, K.T., Grewal, S.K., Suggars, A., Haupricht, S. 2004. Enhanced consistency in biological control of white grubs (Coleoptera: Scarabaeidae) with new strains of entomopathogenic nematodes. Biol. Control 30: 73-82.

Kaya H.K. 1990. Soil ecology. In: Gaugler R and Kaya HK (eds.) Entomopathogenic Nematodes in Biological Control. CRC Press, Florida: 93-115.

Keller, S., Brenner, H. 2005. Development of the *Melolontha* populations in the canton Thurgau, eastern Switzerland, over the last 30 years. IOBC/wprs Bull. 28: 31.

Keller, S., Zimmermann, G. 2005. Scrabs and other soil pests in Europe: situation, perspectives and control strategies. IOBC/wprs Bull. 28: 9-12.

Koppenhöfer, A.M., Kaya, H.K. 1998. Synergism of imidacloprid and an entomopathogenic nematode: A novel approach to white grub (Coleoptera: Scarabaeidae) control in turfgrass. J. Econ. Entomol. 91: 618-623.

Koppenhöfer, A.M., Fuzy, E.M. 2003. *Steinernema scarabaei* for the control of the European chafer. Biol. Control 28: 379-386.

Lakatos, T., Tóth, T. 2006. Biological control of European cockchafer larvae (*Melolontha melolontha* L.) – preliminary results. J. Fruit Ornam. Plant Res. 14: 73-78.

Laznik, Ž., Tóth, T., Lakatos, T., Trdan, S. 2008a. Entomopathogenic nematode *Steinernema feltiae* (Filipjev) (Rhabditida: Steinernematidae) recorded for the first time in Slovenia. Acta Agric. Slov. 91: 37-45.

Laznik, Ž., Tóth, T., Lakatos, T., Trdan, S. 2008b. Entomopathogenic nematode *Steinernema carpocapsae* (Weiser) (Rhabditida:Steinernematidae), a new member of Slovenian fauna. Acta Agric. Slov. 91: 351-359.

Laznik, Ž., Tóth, T., Lakatos, T., Trdan, S (2009): First field experiment with entomopathogenic nematodes in Slovenia. Lect. pap. present. 9th Slov. Conf. Plant Prot., Nova Gorica, March 4-5 2009. Ljubl., Plant Prot. Soc. Slov. (in press). [Slovenian]

Lee, W., Choo, H.Y., Kaya, H.K., Lee, S.M., Smitley, D.R., Shin, H.K., Park, C.G. 2002. Laboratory and field evaluation of Korean entomopathogenic nematode isolates against the oriental beetle Exomala orientalis

(Coleoptera: Scarabaeidae). J. Econ. Entomol. 95: 918-926.

Poinar, G.O. Jr. 1975. Entomogenous Nematodes. E.J. Brill, Leiden, The Netherlands: 317 pp.

Poženel, A. 2007. Experiences in controlling common cockchafer (*Melolontha melolontha* L.) in Idrija region. Lect. pap. present. 8th Slov. Conf. Plant Prot., Radenci, March 6-7 2007. Ljubl., Plant Prot. Soc. Slov.: 72-77 [Slovenian]

Shapiro-Ilan, D.I., Jackson, M., Reilly, C.C., Hotchkiss, M.W. 2004. Effects of combining an entomopathogenic nematodes on mortality of *Curculio caryae* (Coleoptera: Curculionidae). Biol. Control 30: 119-126.

Simard, L., Bélair, G., Brodeur, J. 2001. Susceptibility of the European chafer (Coleoptera: Scarabaeidae) to entomopathogenic nematodes (Rhabditida: Steinernematidae, Heterorhabditidae). J. Nematol. Suppl. 33: 297-301.

Simões, N., Laumond, C., Bonifassi, E. 1993. Effectiveness of *Steinernema* spp. and *Heterorhabditis bacteriophora* against *Popillia japonica* in the Azores. J. Nematol. 25: 480-485.

Trdan S., Vidrih M., Valič N. 2006. Activity of four entomopathogenic nematode species against young adults of *Sitophilus granarius* (Coleoptera: Curculionidae) and *Oryzaephilus surinamensis* (Coleoptera: Silvanidae) under laboratory conditions. J. Plant. Dis. Prot. 113: 168-173.

Trdan S., Vidrih M., Valič N., Laznik Ž. 2008. Impact of entomopathogenic nematodes on adults of *Phyllotreta* spp. (Coleoptera: Chrysomelidae) under laboratory conditions. Acta Agric. Scand., B Soil Plant. Sci. 58: 169-175.

Urek, G., Milevoj, L. 1993. Ogrčja nadloga: poljedelstvo: varstvo. Kmetovalec, 61: 7-8.

Vrabl, S. 1992. Škodljivci poljščin. Ljubljana, ČZP Kmečki glas: 19-22.

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Can we change stereotypes and improve the quality of life?

Marijan JOŠT[1]*

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ABSTRACT

There are a number of generally accepted stereotypes. People base unsustainable behavior on some of them, thereby endangering their own species and all life on Earth. The most dangerous stereotype is that of the present as 'the century of science'. Actually, despite knowledge which doubles each year, thanks to globalization our generation will be the first in the history of humankind to lose more knowledge than it has gained. Based on a stereotype, human arrogance is endangering our existence on Earth. Mankind's treatment of the soil, water and air are clear examples, and this is discussed in detail. If people were to carefully recognize some stereotypes and discard them, the quality of life would gradually improve, and our striving for sustainability would be more realistic.

Out of approximately 250 thousand species of flowering plants, around three thousand are used by man for food. However, by far the largest amount of food for human beings is today supplied by a mere 20 different species. The small numbers of food crops make the human race quite vulnerable to environmental changes. Today, the variety of goods in the supermarket is largely superficial: the 1,500 articles that may be on display represent variations of only a few basic ingredients.

About ten thousand years ago, when people began harvesting the first domesticated plants, the Earth's human population was roughly four million. Today, that many people are born every ten days. If this trend continues after the year 2000, we will have to grow as much food in the first two decades of the new century as was produced over the past ten thousand years.

In light of these facts, the possibilities of and prospects for sustainable agriculture as a principal source of food are discussed.

Key words: agriculture, plant domestication, genetic erosion, environment protection, alternative technologies

ALI LAHKO SPREMENIMO STEREOTIPE IN IZBOLJŠAMO KAKOVOST ŽIVLJENJA?

IZVLEČEK

Obstaja vrsta splošno sprejetih stereotipov. Pri netrajnostnem obnašanju ljudje izhajamo iz nekaterih stereotipov, pri tem pa ogrožamo obstoj svoje lastne vrste in življenja na Zemlji. Najbolj nevaren stereotip je, da naj bi bilo sedanje stoletje "stoletje znanosti". Dejansko bo, kljub temu, da se obseg znanja vsako leto podvoji, naša generacija zaradi globalizacije prva v zgodovini človeštva, ki bo več znanja izgubila kot pridobila. Človeška aroganca ogroža naš obstoj na Zemlji. Naše ravnanje s prstjo, vodo in zrakom so jasni primeri, ki so v članku podrobneje prediskutirani. Če bi ljudje pazljivo stereotipe ugotovili in se tako po njih ne bi več ravnali, bi se kakovost življenja postopoma izboljšala in naša prizadevanja za trajnost bi bili bolj realistična.

Med približni 250 tisoč vrstami cvetnic se jih okoli tri tisoč uporablja za prehrano ljudi. Toda največji del naše prehrane daje samo 20 različnih vrst. Majhno število rastlin za prehrano pomeni, da je človeštvo ranljivo pri izpostavljenosti spremembam v okolju. Danes je izbor izdelkov v supermarketih daleč presežen, med 1.500 razstavljenimi izdelki je le majhna variabilnost glede na nekaj temeljnih sestavin.

Pred približno deset tisoč leti, ko so ljudje začeli spravljati pridelke prvih gojenih rastlin so bili na Zemlji vsega okoli štirje milijoni ljudi. Danes se vsakih 10 dni rodi toliko ljudi. Če se bo ta trend nadaljeval tudi po letu 2000, bomo morali v prvem dvajsetletju novega stoletja pridelati toliko pridelkov, kot jih je bilo skupno pridelanih v zadnjih deset tisoč letih.

Glede na ta dejstva, možnosti in predvidevanja za pomen trajnostnega kmetijstva so v delu prediskutirana izhodišča za zagotavljanje glavnega vira prehrane.

Ključne besede: kmetijstvo, domestifikacija rastlin, genetska erozija, varstvo okolja, alternativne tehnologije

[1]JOST Seed-Research, Križevci, Croatia

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A **stereotype** is a generalized, conventional and oversimplified perception, opinion, or image, based on the assumption of common attributes. It is a common form of social consensus, often a result of social engineering. Generally, it does not allow critical judgment. Let us examine some of them:

DO WE GAIN OR LOSE KNOWLEDGE?

Since Bacon's time (17th century), the world's knowledge acquired through scientific endeavor was not merely the object of contemplation, rather it was put to work so that the human race could ultimately assume mastery and control over nature (Jones, 2005). Over the centuries, this has proved to be both right and wrong. Humankind has been improving its way of life by controlling nature, while at the same time it has been cutting the branch on which it sits.

Today, the general perception or belief is that we live in a century of science. In the past, human race never have had so many research institutions and researchers. Never before has so much been invested to explore and widen new horizons. As a result, the amount of knowledge doubles every five years, while in the field of genetics, the quantity of information doubles every two years (Rifkin, 1998). This is viewed as science marching forward, and anyone who isn't marching forward is a Luddite. Human beings have become arrogant. We have started to behave like a god, and believe that we can change, enhance and improve the world in which we exist.

And then suddenly we are shocked when we read: "In spite of the fact that our knowledge doubles each year, our generation is the first generation in the history of the world to lose more knowledge than it has gained."(Mooney, 2001).

You will argue: No, that's impossible! The revolutions in different areas of science are changing faster and faster: after the revolutions in chemistry, physics, genetics, information technology, and biotechnology, now we are approaching a new revolution in nanotechnology. All this has happened in less than two centuries. (Two decades ago there were no nanotech patents at all. Today, the U.S. Patent Office alone grants more than 150 patents per year. According to the Organization for Economic Co-operation and Development (OECD), governments are now spending over $1.5 billion per annum on nanotech development.) If so, how do we accept this nonsense about lost knowledge?

Let me explain: Due to globalization, the forces eroding our eco-systems, human cultures, and societies are tremendous. In the last century, due to globalization, almost half of the world's languages disappeared (in one-third of Latin America there are no indigenous languages spoken), and half of those remaining will vanish with the current generation.

The joint report of the *Dag Hammarskjöld Foundation* - Uppsala, and the *Rural Advancement Foundation International* – Winnipeg, "The ETC Century – Erosion, Technological Transformation and Corporate Concentration in the 21st Century" argues that, with the erosion of language comes the erosion of our traditional knowledge of the eco-system and our capacity to adapt to climate change and other environmental pressures. It encapsulated the basic knowledge of life and survival collected trough millions of years of evolution transferred from generation to generation. With the extinction of languages, this knowledge is also forgotten (Mooney, 2001). For example: traditional healers – along with language, the knowledge of medical preparations and treatments were lost for ever. Or: The former Andean culture perceives "nature" as a living and highly sensitive being, capable of responding positively when handled well, but also of responding furiously when mistreated. (Paul et al., 2003) While contemporary science across disciplines is once more rediscovering how nature is organic, dynamic and interconnected (Ho and Ching, 2003), some contemporary scientists express the opinion that "Nature is wild, has no brain and man should improve it."

However, the prefix *scientific* for modern systems, and *unscientific* for traditional knowledge systems has less to do with knowledge and more to do with power.(Shiva, 2000) Science has never been more powerful than it is today, and in the future it will be able to do much more than it will be allowed to do (Koshland, 1996). The scientist, by making observations of selected parts or elements of reality, seeks to uncover causal connections between them within the framework of universally applicable laws and theories. Priority is thus given to the parts over the whole (Jones, 2005). Instead of applying a holistic approach, science is becoming increasingly reductionistic.

As critical elements for human survival, powerful new technologies are being brought forward to manipulate our world, exposing them to the possible collapse of our biological environment and our cultural diversity. I am afraid the near future will confirm this.

The ETC Century (Mooney, 2001)
Erosion:
- 90-95 percent of all the species that ever lived are extinct;
- The human race is destroying soil 13 times faster than it can be created;
- Freshwater consumption is almost twice that of its annual replenishment.

Technology transformation:
- Thanks to technological development, or the 'technical revolution' as it is called, as many as 90 thousand species driven to extinction annually. The endangered species we need to worry about is ourselves. If human beings want to stay, we must protect the environment and its diversity.

Corporate concentration:
- 25 years ago, not one of the main seed industries had an identifiable share of the commercial seed market. Today, the top ten seed companies cover one third of world's market (five of them control 100 percent of GM seeds);
- 25 years ago, 65 agricultural chemical companies competed on the world market. Today, nine companies account for 90 percent of pesticide sales.

Science and technology have produced too many unintended side effects on the environment and society, and if the present economic dynamics continues, the final result will be ecological catastrophe (Supek, 1971). Today, as never in the past, the vision of world catastrophe calls for an intervention of common sense (Supek, 1999). Even without the scientist's warnings, it should be clear that we cannot endlessly and unsustainably exploit our habitat resources for short-term economic gain (Schlickeisen, 1992).

In 1847, Justus von Liebig discovered that nutrients removed from the soil by crops could be replaced by minerals in specific rock formations. There are just a few honest scientists like him. The inventor of chemical agriculture, when looking back on his own life and work wrote: "*I have signed against the wisdom of the creator and, justly, I have been punished. I wanted to improve his work because, in my blindness, I believed that a link in the astonishing chain of laws that govern and constantly renew life on the surface of the Earth had been forgotten. It seemed to me that weak and insignificant man had to redress this oversight.*" (From: Agrikulturchemie, 8. Auflage, 1865).

Where are the responsible scientists today? Science without responsibility can be extremely dangerous. If the scientist is dishonest, untruthful, fraudulent, or excessively self-interested, the free flow of accurate information so essential to science will be thwarted (Comstock, 1994).

IN THE HISTORY OF CIVILIZATION THE PLOUGHSHARE HAS BEEN FAR MORE DESTRUCTIVE THAN THE SWORD

This is another surprisingly statement made by Hillel (1991). At first look, it is difficult to believe. But let me explain the facts:

Conversion of natural ecosystems into agricultural ones began ten thousand years ago when our ancestors started to cultivate plants for food. In the beginning, this transformation was slow, occurring only in scattered localities and posing no threat to the wider ecosystem. Naturally created "virgin" soils remained essentially intact until the plow was developed. In time wooden plows were replaced by metal ones, and beasts of burden were used to pull them. In 1837, John Deere began to sell his all steel moldboard plows pulled by horses. Two decades later, a steam engine was used to pull the plow, and by the 1930s, over a million tractors did the job. All this new machinery accelerated the demise of virgin soils (Warshall, 2000).

As early as the fourth millennium BC, Mesopotamia – "the land between the rivers," the Tigris and Euphrates, is widely acknowledged as the "Cradle of Civilization". A warm climate, rich alluvial soils and the availability of a permanent water supply from the rivers gave rise to the development of agriculture among the people of Sumer, Akkad, Babylonia, and Assyria. Since the same plots of land could be cultivated year after year, hunting and gathering societies were replaced by permanent settlements. The availability of surplus food production was probably the most important factor that allowed some members of this society to engage in art and inventions (domesticated animals, the wheel, the wagon, cities, writing, money, etc.). Surplus food deserved the credit for the cultural development of this society (Davis, 2002; Jackson, 2000; Kimbrell, 2000; Warshall, 2000).

But not forever. After about three thousands years of growth, this famous civilization disappeared. Why? Besides increasing crop yields, irrigation was destroying the soil by bringing and depositing tremendous amounts of soluble salts. The three millennia of excessive salinization converted the fertile soil into sterile, not suitable for growing any crop. When soil erosion is in question, the history of the Phoenician, Greek, Carthaginian, and Roman civilizations was quite similar.

The great Plato witnessed land degradation and its consequences, and in one of his dialogues, he proclaimed: "...what now remains of the formerly rich land is like the skeleton of a sick man, with all the fat and soft earth having wasted away. The plains that were full of rich soil are now marshes." (Jackson, 2002).

Learning from history, we can conclude: Every nation that fell did so not only due to political reasons but because their agriculture policies failed (Branden, 2002). Does history repeat itself today? The answer is a categorical YES.

The major conflict between conventional and alternative agriculture in the coming century will involve concern over environmental degradation (Hartel, 1994). To preserve the integrity of the environment, we should be able to apply a holistic approach (which stresses love, compassion and respect for nature) instead of a utilitarian approach ("pesticide use increases yields"), or rights-based ones ("we have the right to use water just as we have always done").

Energy

1. In the USA, 17 percent of total energy consumption are spent for production and distribution of food inside the country.
2. For each energy unit of food on our table, ten energy units were spent in production, and additional thousand energy units in food processing.
3. 12.5 energy units were spent per thousand miles in air transportation of each energy unit of food - more than in production of those food.
4. Organic agriculture permits 2-10 times energy saveing.

Chemical farming technology originated from military use during the twentieth century. Commercial fertilizers became a big business after World War I, as pesticide production did after WW II. The processes and chemicals created in the war were turned into fertilizers and pesticides (Paul et al., 2003). Since 1950, insecticide usage in the US has increased from 8 million kilograms to more than 57 million kg (Jackson, 1985). Their production requires energy. At the end of the twentieth century, farmers used more than 160 liters of oil on average to produce 1 ton of grain. This means it uses more energy than it produces (Comstock, 1994). Today, industrial agriculture uses up to ten times more energy per ton of produced food than organic farming.

Water

World Commission on Water for the 21st Century quotes:

- ½ of the world's rivers and lakes are seriously contaminated by human activities.
- 20% of total rainfall covers the Amazon River basin with only 10 million inhabitants.
- Due to a lack of water, in 2020 the world agricultural production will be reduced to an amount equal to today's production in the United States
- Competition for water between cities, industry and agriculture will increase: in 1950 there were less than 100 cities with over million inhabitants; according to forecasts, in 2025 there will be roughly 650 cities of this size – ½ of the world's population will live in cities

Today, we grow twice as much food as a generation ago, but we use three times more water to do so. Approximately 70 percent of all water used by humans is for crop irrigation. Irrigation of food and livestock feed crops contributes to salinization, an irreversible process accelerated by global warming. Groundwater supplies in major agricultural regions are being, depleted at a much faster rate than their replenishment by rainfall. Every teaspoon full of sugar in your coffee requires 50 cups of water to grow sugar, and 1,120 cups of water to grow coffee (Fowler, 2006).

Different crops require different amounts of water, and some of them are more productive. For instance: with the same quantity of water, sorghum yields 4.5 times more proteins, 4 times more minerals, 7.5 times more calcium, 5.6 times more iron, and 3 times more food than rice (Shiva, 2006).

Today, industrial agriculture turns organic soil, which is a carbon sink, into a carbon source, and generates other green-house gases that exacerbate global warming. (According to the Union of Concerned Scientists <www.ucsusa.org>, since 1995 we have experienced the hottest twelve years on record since 1880.)

Soil (Warshall, 2000)

- Soil is literally alive with a networked complexity greater than that of human brain tissue.
- The number of living creatures (species) is much greater below than above the soil's surface.
- More microbes live in a teaspoon of soil than people on the planet.
- A few centimeters of one square meter fertile topsoil might contain: a thousand each of ants, spiders, beetles and their larvae, two thousand each of earthworms, myriapods, eight thousand snails, 20 thousand pot worms (*Enchytraeids*), 40 thousand springtails (*Collembolas*), 12 million nematodes, 20 million fungi and 5 billion bacteria.

Moreover, earlier research conducted by Iowa State University (1972) estimated that as a result of industrial agriculture, the largest agricultural producer, the United States is losing over four billion tons of soil annually. As an illustration, rendered as freight cars, this would form a train that could encircle the planet twenty-four times (Jackson, 1985). This means that for each ton of exported agricultural goods, 2.5 tons the most fertile surface soil (about 20 tons of soil/hectare/year) are lost by wind or water erosion (Comstock, 2001).

Desertification is becoming a serious threat, and some scientists are forecasting the collapse of American agricultural production within the next half century. The time will soon come when North America will import nearly all agricultural products from less developed countries abroad (Blank, 1998). In the last century, the transformation and disruption of the world-wide environment have become faster and more pronounced. The ancient civilization of Mesopotamia needed three thousand years to reach the same level of soil destruction, while modern Americans will do the same in less than two centuries. Frightening! But the US is not the only example. Desertification in some regions of China is also troubling. Sand dunes lie only 70 miles from Beijing, and they are approaching at a speed of over 3 miles per year.

As Ellen Davis (2002) wrote: "The first eleven chapters of Genesis, that dirty history of early humankind, is in fact the story of dam's progressive alienation from God and fertile soil. Almost every page of the Old Testament sheds light on our relationship to the earth's topsoil, who knows? Maybe today's sad statistics on soil loss will become a religious issue."

THE BIOETHICS OF FOOD PRODUCTION

There are moral and bioethical concerns. The things now wrong with agriculture all come from the human willingness to manipulate nature, i.e. to convert health into wealth (Jackson, 1985). Not so recent reports suggest that billions of people in the world could be fed with the food produced by new wonder cultivars and industrial agriculture technology.(Avery, 1985) At the same time, other reports suggest that industrialized agriculture is not sustainable because of its impact on the world's resources and environment - air, water, soil and biological diversity (Blatz, 1994).

It is up to you to decide which is the right way to follow. The decision is not easy, but is fateful. Sustainable agriculture is closely correlated with moral sustenance.

In order to feed the world, we must invest in sustainable agriculture across the globe, which will also ameliorate the worst consequences of climate change (Ho and Ching, 2003).

Dr T. R. Preston, Director of theUniversity of Tropical Agriculture Foundation in Phnom Penh, Cambodia explained: „As long as 'farmers' (more so those in agribusiness) continue to feed half the world supply of grain to livestock to produce food which is subsidized, for consumption by people most of whom are over-fed, and many of them severely obese, there is no basis for justifying GM technology as a necessary means to save the world's poor from hunger.

CAN AGRICULTURAL DEVELOPMENT BE SUSTAINABLE?

This is a difficult question and the answer depends upon the period under observation. Two items are critical:

1) Population growth: Consider that during the second millennium, each doubling of the population took roughly half as long as the previous doubling. In the nineteenth century, global population growth was 0.672 billion, while in the twentieth century it was 4.4 billion (a 6.5 fold increase).

How far can this population increase go? In order to secure the foods supply, should humankind be forced to control it?

Table 1. *Global population growth per century (in billions)**

Year	1800	19th century	1900	20th century	2000
Population	0.978		1.650		6.050
Growth difference per century		0.672		4.400	

* United Nations Population Division <http://www.un.org/spanish/esa/population/wpp2000at.pdf >

2) Environmental degradation: As it was proven by history, technologies can solve problems, but can create new (bigger) ones as well. Powerful new technologies are being brought forward to manipulate our world. Science and technology has produced too many unintended side effects on the environment, changing it in an undesirable way. The speed of these changes is increasing rapidly, while most scientists have been "social sleepwalkers" - avoiding the social impact of their research while benefiting from commercialization (Mooney, 2001).

In June 2001 at Göteborg, the European Council, in order to create a sound balance between knowledge-based economic growth and environmental and social needs, discussed the European Strategy for Sustainable Development. It states: "The Common Agricultural Policy and its future development should, among its objectives, contribute to achieving sustainable development by increasing its emphasis on encouraging healthy, high quality products, environmentally sustainable production methods, including organic production, renewable raw materials and the protection of biodiversity."(EC, 2001; EC 2007). Nice words. However, in spite of the fact that sustainable development is accepted as a fundamental objective of the European Union, after six years the conclusions of the Progress Report (October 2007) of the European Council shows that progress on the ground has been modest (EC, 2007).

On April 15, 2008, 400 scientists in the International Assessment of Agricultural Science and Technology for Development (IAASTD) released a 2,500-page report that took four years to complete (IAASTD, 2008). Its conclusions were: Natural resources (soil, water, biological diversity, vegetation cover, renewable energy, climate, and ecosystem services) are fundamental for the structure and function of agricultural systems and for environmental sustainability. It calls for a fundamental change in farming practices to counteract hunger, poverty and environmental disasters. It recognizes the importance of traditional and local knowledge - knowledge-generating capacity that is needed if sustainability and development goals are to be achieved (IAASTD, 2008).

Obviously, today sustainable development has become a hot topics acknowledged by politics and science. But I am afraid that, observed over a longer period (thousands of years), sustainable development is an illusion. Farming doesn't work the way nature does: it doesn't create its own self-replenishing cycle. Today, the development of human society is at the expense of the environment and biological diversity, and cannot be sustainable.

However, there are more optimistic views. The creator of Dream Farm 2, Mae-Wan Ho was inspired by two ideas: 1) The "circular economy" of Japanese farmer Takeo Furano works perfectly on his 2 ha farm. The system is absolutely dependent on the natural biodiversity of species working to benefit one another: ducklings to work in paddy fields, resulting in harvests of 7 ton of rice, 300 ducks, 4,000 ducklings, countless fish, and enough vegetables for 100 people. Best of all, he and his family get plenty of free time from not having to do any weeding, because the ducklings eat all of the weeds and pests. The ducks not only eat the weeds and pests, they fertilize the water to feed the rice plants, the rice plant attract pests, which make more food for the ducks. The ducks also feed the plankton in the water, which feed the fish, and sometimes fish fries get eaten by the ducks. The circular economy system works by reciprocity and mutual benefit (Ho et al., 2008).
2) The "Integrated Food and Waste Management System" of Professor George Chan. The biogas digester

is the heart of the system, and it reinforces the circular economy and makes it more efficient. In the biogas digester, livestock manure and other organic waste are converted into biogas (60 percent methane), which can provide all of the energy needed for cooking, heating, electricity and processing. The residue in the digester is rich compost. The system relies entirely on internal input, recycling all of the waste and turning waste into food and energy resources. This approaches the ideal of the sustainable system, which operates like an organism.

The large lifecycle consists of many different cycles of activities coupled together and working together. The more lifecycles that are linked into the grand cycle, the more productive the land, and activities that yield energy are directly linked to those requiring energy, and all of the cycles feed one another. In this Dream Farm 2, a wind, hydro and solar energy could be included also, where appropriate (Ho et al., 2008).

CONCLUSION

What is right and acceptable is what produces good consequences: access to basic human needs, sustainability to protect future generations, and protection of biodiversity (Blatz, 1994). The main question is: how agriculture can feed the world today, and maintain sustainability for tomorrow. In the coming century, the major conflict between industrialized and traditional agriculture will be the concern for environmental degradation, and industrialized agriculture will be forced to adopt some traditional agriculture practices (Hartel, 1994). In this sense we can distinguish two main types of agriculture:

1) ***Agriculture as business*** *(industrialized, conventional agriculture)* – If we accept agriculture as business, then we should accept all of the accompanying phenomena:
   - competitiveness (speed, quantity, profit),
   - centralization (control of land resources and capital), and
   - specialization (narrow field products dependent on science and technology).

   The only values considered are yields; the cost and impact of pesticides and fertilizers on soil, water, biological and agricultural diversity, and human health are discounted or externalized (Paul et al., 2003). The engine that drives agriculture-as-business is **profit**, and its philosophy is investment of capital in order to get the highest possible return. But, land and water degradation, as well as loss of biological diversity, are not considered as an economic loss. This agriculture is not sustainable and cannot last forever. It is not primarily concerned with continuing to use the same resources now and in the future. Industrialized agriculture favors the momentary (not lasting) goods of human well-being over those of ecological integrity and non-human welfare (Aiken, 1984).

2) ***Agriculture as a way of life.*** Alternatively, we may regard agriculture not as business, but as a way of life. In that case, its characteristics are:
   - community (emphasis on permanence, quality, and beauty),
   - decentralization (dispersed control of land, resources, and capital),
   - non-specialization, and
   - emphasis on personal knowledge and local wisdom (Beus et al. 1991).

Agriculture as a way of life is labor-intensive rather than capital and technology intensive, oriented to the local market, more diverse, and more organic. It respects Mother Nature and is more sustainable.

It is not hard to understand which of the approaches to agriculture must be followed if we are to survive as a species. The values of agriculture for the next century must be:

a) Health of the land
b) Welfare of future generations
c) Social and interspecies justice and
d) Integrity in meaningful work and relationships (Freudenberger, 1986).

The father of modern taxonomy, Carl von Linné – the man who gave us the binomial system of nomenclature also gave us our name: ***Homo sapiens***. Sapiens means wise, sage, or knowing. Did the great Linnaeus get it right? That is up to us. It depends on whether we solve our oldest environmental problem — the problem of agriculture (Jackson, 2000).

5 REFERENCES

Aiken, W. 1984. Ethical issues in agriculture. In T. Regan (ed.); Earthbound: New introductory essays in environmental ethic. Random House, New York, p. 247-288.

Avery, D. 1985. U.S. farm dilemma: The global bad news is wrong. Science, Washington DC, 230:408-412.

Beus, C.E., R.E. Dunlap, R.M.Jimmerson, and W.L. Holmes. 1991. Competing paradigms: The debate between alternative and conventional agriculture. Res. Bull.XB1020. Washington State University, Pullman.

Blank, S.C. 1998. The End of Agriculture in the American Portfolio. Quorum Books, p.232.

Blatz, C.V. 1994. Coming full circle: Ethical issues in traditional and industrialized agriculture. In: P.G.Hartel et al. (Eds) Agricultural ethics: Issues for the 21st century. ASA Spec. Publ. No.57, pp. 33-42.

Branden, N.P. 2002. The letter to David Kendra, USDA, Tulare, August 18.

Commission of the European Communities. 2001. A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development (Commission's proposal to the Göteborg European Council). Brussels, May 15. http://europa.eu/eur-lex/en/com/cnc/2001/com2001_0264en01.pdf

Commission of the European Communities.2007. Progress Report on the Sustainable Development Strategy 2007. Brussels, 22.October. http://ec.europa.eu/ sustainable/ docs/com_2007_642_en.pdf

Comstock, G. 1994. Some virtues and vices of agricultural technology. In: P.G.Hartel et al. (eds) Agricultural ethics: Issues for the 21st century. ASA Spec. Publ. No.57, pp. 25-32.

Comstock, G. 2001. Ethics and genetically modified foods. SCOPE GM Food Controversy Forum, July 1st. <http://scope.educ.washington.edu/gmfood/>

Davis, F. Ellen. 2002. The Bible and our topsoil. Prairie Writers Circle, Cropchoice, November 11,

Fowler, C. 2006. The genetics of water, Global crop diversity trust. http://www.croptrust.org/documents/newsletter/ newsletter_croptrust_v1_final.htm

Freudenberger, C.D. 1986. Value and ethical dimensions of alternative agricultural approaches: In quest of a regenerative and just agriculture. In K. Dahlberg (ed.): New directions for agriculture and agricultural research: Neglected dimensions and emerging alternatives. Rowman & Allanheld, Totowa, NJ, p. 348-364.

Hartel, P.G. 1994. Overview. In P.G. Hartel et al. (eds.), Agricultural ethics: Issues for the 21st century. ASA Special publication No.57:1-10.

Hillel, D.J. 1991. Outh of the Earth: Civilization and the life of the soil. Free Press, New York. NY, USA.

Ho, M.W. and J. Cummins. 2001. The unnecessary evil of 'therapeutic' human cloning. ISIS Report Jan.; ISIS News #7 http://www.i-sis.org/stemcells-pr.shtml

Ho, M.W and Lim Li Ching. 2003. The case for a GM-free sustainable world. Institute of Science in Society & Third World Network, London and Penang, p. 115.

Ho, M.W., S. Bucher and Ching L.L. 2008. Food Futures Now. ISIS & TWN, p. 178.

International Assessment of Agricultural Knowledge, Science & Technology (IAASTD) Synthesis Report 25 November 2007, http://www.agassessment.org/docs/ Synthesis_ Report_261107_text.pdf

IAASTD. 2008. Executive Summary of the Synthesis Report of the International Assessment of Agricultural Knowledge, Science and Technology for Development. Johannesburg, South Africa, 7-11 April. Island Press, p.24. http://www.agassessment.org/docs/IAASTD_ EXEC_SUMMARY_JAN_2008.pdf

Jackson, W. 1985. New roots for agriculture. University of Nebraska Press, Lincoln-London, p. 150.

Jackson, W. 2000. Acceptance Speech. The Right Livelihood Awards, December 8th. http://www.rightlivelihood.org/ jackson_speech.html

Jackson, W. 2002. Natural Systems Agriculture: A radical alternative. Agriculture, Ecosystems and Environment, Vol. 88, pp. 111-117.

Jones A. 2005. Mutualism and Interdependence: a Gaian critique of Science and Society. 1st Southeast European Bioethics Forum, Mali Lošinj, June 16-18. (Personal communication)

Kimbrell A. 2000. Water – The overtapped resource. In: A. Kimbrell (ed.) Fatal harvest – The tragedy of industrial agriculture. Island press, Washington, Covelo, London, pp. 229-234.

Koshland, D.E. 1996. Ethical decision making in a pluralistic society. In: F.B. Rudolph and L.V. McIntire (Eds.) Biotechnology: science, engineering and ethical challenges for the twenty-first century. Washington. p.p. 191-198.

Mooney, P.R. 2001. The ETC Century – Erosion, technological transformation and corporate concentration in the 21st century. Dag Hammarskjöld Foundation, Uppsala, and Rural Advancement Foundation International, Winnipeg, p. 128

Paul, Helena, Richarda Steinbrecher, D. Kuyeke and Lucy Michaels. 2003. Hungry corporations. Transnational biotech companies colonise the food chain. Zed Books, London & New York, p. 242.

Pimbert, M. 2009. Towards Food Sovereignty - Reclaiming autonomous food systems. International Institute for Environment and Development, London, p.63.

Presidency Conclusions. 2001. European Council Göteborg. 15 and 16 June. http://www.europarl.europa.eu/summits/pdf/got1_en.pdf

Rifkin, J. 1998. Harnessing the gene and remaking the world – The biotech century. Tarcher – Putman, New York, p.271

Schlickeisen, R. 1992. The earth ethic. Defenders Magazine, Nov./Dec. <http://www.defenders.org/rsnd92.html>

Shiva Vandana. 2000. Monocultures of the mind. TWN, Malaysia, Zed Books Ltd. London and New York, (4th eddition) p.184.

Shiva, Vandana. 2006. Ratovi za vodu – Privatizacija, zagađivanje i profit. DAF, Zagreb, p.177.

Supek, I. 1971. Spoznaja. Mladost, Zagreb.

Supek, I. 1999. Mene Tekel Fares. Naklada MD, Zagreb.

Warshall, P. 2000. Tilth and technology – The industrial redesign of our nation's soils. In: A. Kimbrell (ed.) Fatal harvest – The tragedy of industrial agriculture. Island press, Washington, Covelo, London, pp. 221-228.

Author address:
Marijan Jost < marijan.jost@kc.t-com.hr >
Stjepana Radica 21
48260 Krizevci, Croatia

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Soil organic matter changes according to the application of organic and mineral fertilizers within long-term experiments

Monika CVETKOV[1], Anton TAJNŠEK[2]

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ABSTRACT

Within the long-term field experiments at IOSDV Jable near Ljubljana (subalpine climate, heavy hydromorphic silt loam) and at IOSDV Rakičan (Pannonian climate, sandy silt), the impact of organic matter management system and mineral nitrogen fertilization on the soil organic matter content was studied in the period 1998-2008. The following management systems were selected: system A - no organic matter, system B - farmyard manure ploughing in, system C - straw/catch crop ploughing in. Four different mineral N rates (N0, N1, N2, N3) were evaluated. During the three-year crop rotation, maize, wheat and barley (or, alternatively, oats) were sown each year. The annual balance of C_{org} was calculated on the basis of the quantity of added organic and mineral fertilizers, considering the quantity of C_{org} in the soil. In system A, at both locations, fertilizing with the highest amount of mineral N resulted in a higher C_{org} content. At both locations, positive effect of organic fertilization on the increase of the C_{org} content was registered where management systems with organic matter (i.e. systems B and C) applied, while statistically significant impact of mineral N on a higher C_{org} content was determined only in system C. Within all three systems, the highest C_{org} values were reached when the highest mineral N application volume was used. After 11 years, the C_{org} content in system A decreased irrespective of the mineral N fertilization at both locations. At IOSDV Jable, a small decrease of the C_{org} content was measured in BN0, while all other treatments at IOSDV Jable and at IOSDV Rakičan resulted in an increased C_{org} content.

The average absolute value of difference among the C_{org} contents in 2008 and 1998 in all ten treatments at IOSDV Jable was 1.8 t/ha C_{org}, while at IOSDV Rakičan it amounted to 3.5 t/ha C_{org}, which indicates a major influence of management system on the soil with a smaller clay content.

Key words: soil fertility, crop rotation, organic fertilizers, farmyard manure, straw, N fertilizers, humus content, humus balance

IZVLEČEK

SPREMEMBE VSEBNOSTI ORGANSKE SNOVI V TLEH V ODVISNOSTI OD GNOJENJA Z ORGANSKIMI IN MINERALNIMI GNOJILI ZNOTRAJ TRAJNIH POSKUSOV

V statičnem poskusu IOSDV Jable, blizu Ljubljane (predalpsko klimatsko območje, ilovnato meljasta hidromorfna tla) in IOSDV Rakičan (panonsko klimatsko območje, meljasto ilovnata tla) smo preučevali vpliv gospodarjenja z organskimi gnojili in vpliv gnojenja z mineralnimi dušikom na vsebnost organske snovi v tleh v letih 1998 do 2008. Vključeni sistemi gospodarjenja so bili: sistem A - gospodarjenje brez organskega gnojenja, sistem B - gnojenje s hlevskim gnojem, sistem C - zaoravanje slame/podorin. Preučevane so bile štiri stopnje gnojenja z mineralnim dušikom: N0, N1, N2 in N3. V triletnem kolobarju si sledijo koruza, pšenica, ječmen/oves. Letna bilanca C_{org} je bila izračunana na podlagi količin dodanih organskih in mineralnih gnojil, pri upoštevanju stanja C_{org} v tleh. Na obeh lokacijah je v sistemu A gnojenje z največjim odmerkom mineralnega dušika povečalo vsebnost C_{org} v tleh. Na obeh lokacijah je bil dokazan vpliv organskega gnojenja na povečanje vsebnosti C_{org}, v sistemih B in C, medtem ko je bil značilen vpliv gnojenja z mineralnim dušikom dokazan le v sistemu C. Najvišje vsebnosti C_{org} znotraj sistemov so bile pri obravnavanju z največjim odmerkom mineralnega dušika. Po enajstih letih se je vsebnost C_{org} v sistemu A na obeh lokacijah zmanjšala, ne glede na gnojenje z mineralnim dušikom. Vsebnost C_{org} je po enajstih letih narasla v vseh obravnavanjih sistemov B in C, razen pri obravnavanju BN0 v IOSDV Jable. Povprečna absolutna razlika vsebnosti C_{org} med letoma 2008 in 1998 znotraj vseh deset obravnavanj v IOSDV Jable je 1,8 t/ha C_{org}, v IOSDV Rakičan pa 3,5 t/ha C_{org}. Rezultati nakazujejo, da je vpliv različnega sistema gospodarjenja večji na lokaciji IOSDV Rakičan, kjer vsebujejo tla manjši odstotek gline.

Ključne besede: rodovitnost tal, kolobar, organska gnojila, hlevski gnoj, slama, mineralni dušik, vsebnost humusa, bilanca humusa

[1] University of Ljubljana, Biotechnical Faculty, Jamnikarjeva 101, SI-1111 Ljubljana, e-mail: monika.kunaver@bf.uni-lj.si

[2] University of Ljubljana, Biotechnical Faculty, Jamnikarjeva 101, SI-1111 Ljubljana, e-mail: tone.tajnsek@bf.uni-lj.si

1 INTRODUCTION

Soil organic matter (SOM) is one of the most important determinants of soil quality and is most commonly estimated by determining the soil organic carbon (SOC) content (Rasmussen et al., 1998). A usable way to calculate SOM is by multiplying the percentage of organic carbon by a factor; however, conversion factor varies between 1.6 and 3.3 and this large range is due to the inherent differences between soils and humus composition. Most commonly, a conversion factor 1.72 is used (Körschens et al., 1997; Körschens, 2001; Rasmussen et al., 1998). Definition of soil organic carbon requires a differentiation into two fractions: decomposable organic carbon (C_{decom}), which is mainly influenced by cultivation conditions and inert part of carbon (C_{iner}), which is uninvolved in mineralization and mostly dependent on the site conditions (Körschens, 1997).

It is widely recognized that SOC plays an important role in biological (provision of substrate and nutrients for microbes), chemical (buffering changes, soil porosity) and physical (stabilization of soil structure, soil thermal conditions) properties of the soil (Reeves, 1997). Considering this wide variety of performance indicators, Karlen (Karlen et al., 2003) pointed out that soil quality needs to be assessed with regard to what the soil is used for, as a particular type of soil may be of high quality for one function and may perform poorly for another. Critical levels of soil organic carbon content are difficult to establish since they vary according to soil texture and climatic conditions (Kay and Angers, 1999; Körschens , 1997; Ogle et al., 2005, Rasmussen et al., 1998).

It is recommendable to maintain a 1.5 to 3.5 % SOC content in topsoil, with the value varying in accordance with the soil structure (Tajnšek, 2003). According to Körschens (Körschens et al., 1997), the upper and the lower values of SOC differ in relation to clay contents; for soils with 4 % of clay, the proposed limits of SOC are between 1 % and 1.5 %, while for soils with more than 38 % of clay, the limit values of SOC are between 3.5 % and 4.4 %. Due to a slow response of organic carbon to the production management, monitoring of humus content requires long-term, several-decade lasting experiments (Körschens, 2001; Powlson et al., 1998; Ogle et al., 1998). Crop rotation, fertilization with organic and mineral fertilizers, a manner and time of ploughing and ploughing in of harvest residues or catch crops are factors that influence the content of SOC. Having replaced the conventional soil tillage with shallow or minimum tillage, soil humus content in the soil layer to 10 cm significantly increased (Angers and Carter, 1996; Campbell et al., 1996; Riley et al., 2008; Slepetiene and Slepetys, 2005). However, Schulz (Schulz et al., 2008) points out that significant differentiation of SOC content by tillage intensity could not be confirmed.

Bucur et al. (2007) studied the influence of soil erosion on humus losses in different crop systems in Romania; the highest losses were registered in continuous maize culture. Körschens (1997) thoroughly studied the influence of different crops on the decomposable SOC; clover (lucerne, alfaalfa) as a perennial crop with a wide root system proved to have the highest SOC content in comparison with cereals and row crops. With the application of organic manure, the SOM content increased (Delschen, 1999; Edmeades, 2003; Gerzabek ,1997; Körschens, 1997; Kristaponyte, 2005; Martens and Frankenberger, 1992; Nardi et al., 2004; Paustian et al., 2005). The application of higher amounts of mineral fertilizers (NPK or N) increase SOC amount (Haynes and Naidu, 1998; Purakayastha et al., 2008), while, according to Shevtsova and Nardi (Shevtsova et al., 2003; Nardi et al., 2004), fertilizing with mineral fertilizers had no significant effect on the humus content compared to the application of organic fertilizers.

As the humification (changing the primary organic matter into humus) and mineralization (changing humus into soil minerals) depend largely on the amount of precipitation, it is necessary that the latter are taken into account when interpreting the results (Zech, 1997). Under the average European climatic conditions the decomposable carbon in SOC is 0.2 %-0.6 %, corresponding to 8 to 24 t/ha (Körschens, 1997). By using methods of calculating the balance of humus we are given an opportunity to control the SOM content in arable soils in order to achieve higher yields and simultaneously avoid environmental pollution. In the trial, the method of calculating the balance of humus determined by Diez and Krauss was used (Diez and Krauss, 1992); this method, which we named the “Swiss method”, is believed to be an appropriate method for the central Slovenian climatic conditions.

The aim of our study was to examine, with the application of the “Swiss method”, the impact of organic and mineral fertilization on the humus content in the soil according to particular crop rotation at two different locations with a specific soil type and particular climatic conditions.

2 MATERIALS AND METHODS

2.1 Experimental layout

Two long-term experiments were established at IOSDV Jable and IOSDV Rakičan in 1993.

The trial was set up as a permanent experiment related to crop rotation with ten different fertilization combinations as a block trial with three repetitions. First, the trial area was divided into three plots, on which each year crops were sown in the following order: corn, winter wheat, barley/oats. Each plot was further divided into two subplots, on which different systems of fertilization with organic management were studied. Each subplot thus represented five variants differing according to the rate of fertilization with mineral nitrogen in the three repetitions. The basic plot size was 30 m^2 (5 × 6 m). Ten different treatments were included in the investigation:

- management system with no organic fertilizers (system A) and two different mineral rates (N0, N3),
- management system with farmyard manure ploughing in (system B) and four different mineral N rates (N0, N1, N2, N3),
- management system with straw ploughing in (system C) and four different mineral N rates (N0, N1, N2, N3).

Fertilizing plan for the nutrition of arable crops is shown in Table 1. At the harvest time, yield and straw quantities were measured for each plot. After harvesting every year soil samples from each plot were taken at a depth of 0-25 cm for further analysis.

***Table 1**: Management systems, mineral N fertilization with regard to the crop, the average amount of mineral N in the three-year crop rotation (Miner. $N_{aver.}$) at the IOSDV Jable and IOSDV Rakičan locations for ten treatments.*

		Miner. N rates	Maize (kg/ha N)	Wheat (kg /ha N)	Barley/ Oats (kg /ha N)	Miner. $N_{aver.}$ (kg /ha N)	Treat.
System A	No organic fertilizers		/	/	/		
		N0	0	0	0	0	**AN0**
		N3	300	195	165	220	**AN3**
System B	Farmyard manure ploughing in (t/ha)		30 t/ha farmyard manure	/	/		
		N0	0	0	0	0	**BN0**
		N1	100	65	55	73	**BN1**
		N2	200	130	110	147	**BN2**
		N3	300	195	165	220	**BN3**
System C	Straw/catch crop ploughing in (t/ha)		Barley/oats straw + fodder radish	Maize straw	Wheat straw		
		N0	0	0	0	0	**CN0**
		N1	100	65	55	73	**CN1**
		N2	200	130	110	147	**CN2**
		N3	300	195	165	220	**CN3**

2.2 Humus balance calculation method

The method of calculating the balance of humus was determined by Diez and Krauss (Diez and Krauss, 1992). We named it the "Swiss method". The annual balance (H_n) is calculated on the basis of the ploughed-in quantity of organic matter (manure (Z_d), straw (Z_e), catch crop (Z_e), harvest residues (Z_e)) with the corresponding humification coefficient (H_{Kd}, H_{Ke}), taking into account the quantity of humus in the soil (H) with the appropriate mineralization coefficient (H_{Mk}). Results are given in the C_{org} value (t/ha), which is calculated on the basis of humus content (t/ha) multiplied by factor 0.58. The equation for calculating the balance of humus is shown in Table 2.

In the year of establishment of the experiment (1993) the soil analysis were conducted at the laboratories UFZ Leipzig-Halle, Germany (Tajnšek, 2003); the C_{org} content was determined according to ISO 10694, 1996-08. In the calculation of humus balance we considered this initial value of C_{org} in 1993 content, while presented results are for the period 1998-2008.

Statistical analysis was conducted with the Statgraphics Plus 4.0 program. Multifactor ANOVA was used in order to analyze the effect of different management systems on the humus content in the soil. Differences among treatments were detected by Duncan's Multiple Range Test ($p < 0.05$).

***Table 2**: The equation for the humus balance calculation with the corresponding parameters for each of the three management systems (system A, B, C) (modified by Diez and Krauss, 1992).*

Eq:	(Ze	×	Hke)	+	(Zd	×	Hkd)	-	(H	×	Mkh)	=	H_n
	Annual amount of plant residues (straw, catch crop, harvest residues)		**Humification coefficient forplant residues**		**Annual amount of farmyard manure**		**Humification coefficient for farmyard manure**		**Amount of humus per hectare in the previous year n-1**		**Mineralization coefficient for an individual crop sown in a particular year**		**Amount of humus in year n**
System A	(roots[1]	×	0.02)					-	(HA_{n-1}	×	0.01)	=	HA_n
System B	(roots	×	0.02)	+	(farm. manure[2]	×	0.25)	-	(HB_{n-1}	×	0.01)	=	HB_n
System C	(roots	×	0.02) +					-	(HC_{n-1}	×	0.01)	=	HC_n
	(straw	×	0.15) +										
	(fodder radish[3]	×	0.1)										

[1]The amount of straw t SS/ha × roots/straw ratio coefficient (0.5).
[2]The amount of farmyard manure 7.5 t SS/ha is considered only for maize (in the years 1999, 2002, 2005, 2008).
[3]Ploughing in of fodder radish as a catch crop is considered only after barley/oats (in the years 1998, 2001, 2004, 2007).

2.3 Weather and soil conditions

For the chemical and physical properties of the soil measured at the beginning of the trial cf. Tajnšek (2003). The soil type at the IOSDV Jable location (46 ° 8'N, 14 ° 34'N, 305 m above sea level) is *Umbric Planosols (Plu)*, while soil texture is determined as silt loam. The soil type at the IOSDV Rakičan location (46°38´N, 14°11´N, 184 m above sea level) is *Eutric Fluviosol (ELe)*, while soil texture is determined as sandy silt.

IOSDV Jable is located in the subalpine zone, where prolonged droughts are rare even in the summer, let alone in the winter and autumn. Its reference weather station is Brnik. In the period 1961-1990, the average annual temperature was 8.3 °C and ranged from 7.3 °C to 9.8 °C. The long-term average precipitation during the period 1961-1960 amounted to 1384 mm in the 987 mm to 1770 mm interval. During the trial period (1998-2008), the average annual temperature was more than 1°C higher compared to the long term average. In the years 2000, 2002, 2003 and 2008, the average annual temperature ranged from 9.7 °C to 10.2 °C. In the years studied, the average annual precipitation was 1323 mm; in 2004, 2005, 2008, on the other hand, it was 8-17 % higher in comparison with the long term average.

IOSDV Rakičan is located on the south-western edge of the Pannonian climate zone. Its reference weather station is Murska Sobota. In the period 1961-1990, the average annual temperature was 9,2 °C, ranging from 8.2 °C to 10.1 °C. The long-term average precipitation during the period 1961-1990 was 814 mm in the 563 mm to 1064 mm interval. From 1998 to 2008, the average annual temperature was 1.3 °C higher in comparison with the long-term average temperatures. The hottest years were 2000, 2002, 2007 and 2008, with average annual temperatures above 11 °C. In the years studied, the average annual precipitation was 747 mm; in 2003, however, it was approximately 30 % smaller compared to the long-term average precipitation.

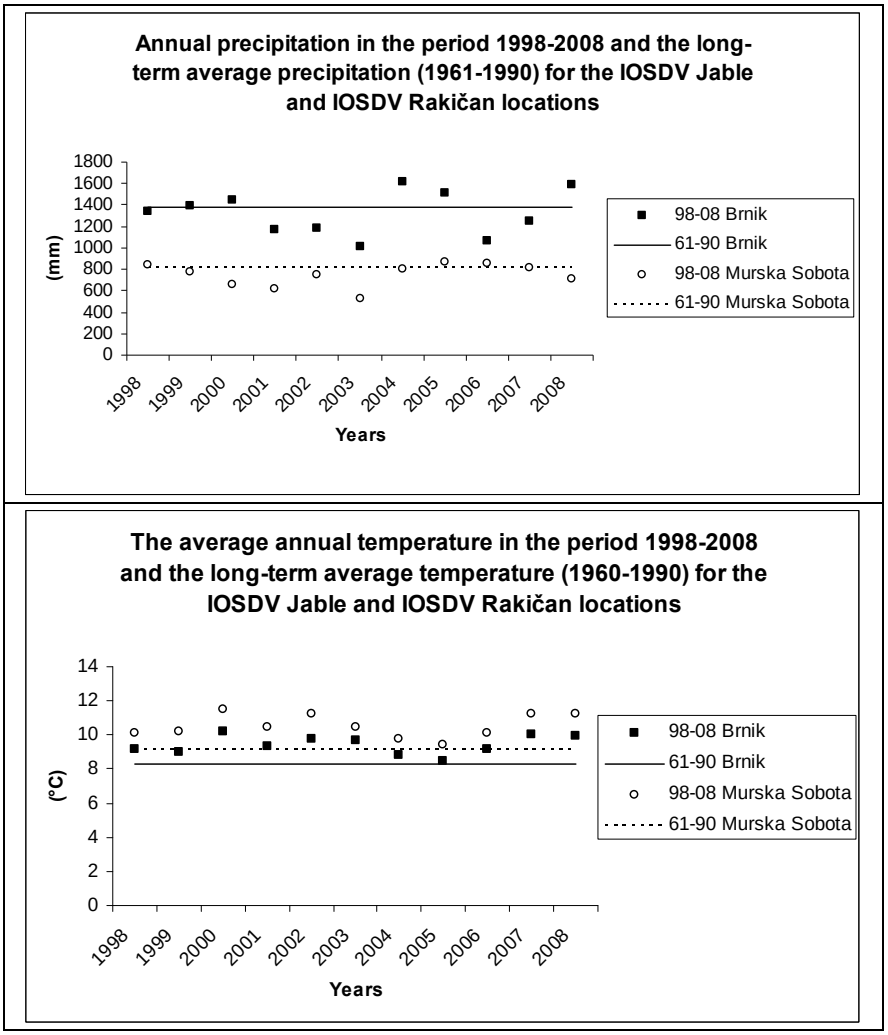

Figure 1: *Annual precipitation for the period 1998-2008 and the long-term average precipitation (1961-1990) for the IOSDV Jable (weather station Brnik) and IOSDV Rakičan (weather station Murska Sobota) locations (above) and the average annual temperature for the period 1998-2008 and the long-term average temperature (1960-1990) for both locations (below).*

3 RESULTS AND DISCUSSION

3.1 IOSDV Jable

Results showing the C_{org} content at the IOSDV Jable location for the period 1998-2008 and the average C_{org} content for the period of 11 years are given in Table 3. The initial value of C_{org} at the beginning of the trial in 1993 was 55.48 t/ha C_{org}. Over the period 1998-2008, the impact of organic and mineral fertilization on the content of C_{org} was confirmed. In system A, fertilizing with mineral nitrogen significantly affected the increase of the C_{org} content. On average, the C_{org} content rose from 50.6 t/ha C_{org} in an AN0 control to 52.2 t/ha C_{org} in AN3, which corresponds to 3.2%.

Table 3: *The C_{org} content (t/ha) during the period 1998-2008 and the average C_{org} content (t/ha) for the same period for ten treatments (including three different management systems: A, B, C and nitrogen fertilization: N0, N1, N2, N3) at IOSDV Jable at a depth of 0-25 cm, calculated by the "Swiss method".*

	IOSDV Jable C_{org} (t/ha)											
Treat.	**1998 Bar.**	**1999 Mai.**	**2000 Whe.**	**2001 Bar.**	**2002 Mai.**	**2003 Whe.**	**2004 Oats**	**2005 Mai.**	**2006 Whe.**	**2007 Oats**	**2008 Mai.**	**Aver 11yr.**
AN0	53.02 a* ±0.08	52.48 a ±0.10	51.99 a ±0.12	51.48 a ±0.11	50.95 a ±0.12	50.50 a ±0.12	50.12 a ±0.14	49.61 a ±0.19	49.13 a ±0.18	48.43 a ±0.18	48.43 a ±0.20	50.60 a ±0.14
AN3	53.70 b	53.54 b	53.15 b	52.69 b	52.39 b	52.02 b	51.77 b	51.67 b	51.31 b	51.29 b	51.02 b	52.23 b
BN0	54.17 c	54.74 d	54.23 d	53.72 d	54.31 d	53.84 d	53.43 d	53.99 d	53.48 d	53.22 d	53.80 d	53.91 d
BN1	54.44 d	55.13 e	54.67 e	54.17 e	54.83 ef	54.40 e	54.05 e	54.71 e	54.27 e	54.15 e	54.79 e	54.51 e
BN2	54.60 de	55.39 ef	54.95 ef	54.50 f	55.19 fg	54.78 f	54.45 ef	55.15 ef	54.75 ef	54.63 e	55.38 ef	54.89 ef
BN3	54.70 e	55.57 f	55.17 f	54.75 f	55.50 g	55.10 f	54.79 f	55.65 f	55.26 f	55.28 f	56.03 g	55.25 f
CN0	54.13 c	53.90 c	54.84 c	53.22 c	53.04 c	52.70 c	52.64 c	52.78 c	52.36 c	52.57 c	52.53 c	53.04 c
CN1	55.11 f	55.09 e	54.84 ef	54.58 f	54.55 de	54.29 e	54.46 ef	55.05 e	54.77 ef	55.33 f	55.48 fg	54.87 ef
CN2	55.44 g	55.98 g	55.77 g	55.55 g	55.88 h	55.65 g	55.84 g	56.73 g	56.55 g	57.47 g	57.89 h	56.25 g
CN3	55.74 h	56.69 h	56.47 h	56.29 h	56.88 i	56.63 h	56.88 h	57.68 h	57.51 h	58.51 h	59.10 i	57.13 h

*a-i – The same letter in the column indicates that there is no significant difference among treatments (Duncan multiple range test. $p<0.05$).

In the system with farmyard manure ploughing in (system B), the C_{org} content was, in all treatments, significantly higher compared to the C_{org} content in system A. In 2001 and 2003, fertilization with a higher amount of mineral nitrogen (BN2, BN3) demonstrated a positive impact on the increase of the C_{org} content; in 2007 and 2008, on the other hand, only the treatment with the highest amount of mineral nitrogen (BN3) proved to have the same effect. In other years, the mineral nitrogen fertilization influenced the C_{org} content; the differences among treatments could, however, not be statistically confirmed. The C_{org} content in system B increased by an average of 3.3 t/ha C_{org} to 4.7 t/ha C_{org} compared to the average C_{org} content in AN0.

In the system with ploughing in of straw and catch crops (system C), the C_{org} content was, in all treatments, significantly higher compared to the C_{org} content in the AN0 control. Unlike system B, differences among treatments (CN0, CN1, CN2, CN3) in system C were statistically confirmed in all the studied years. Increasing the amount of mineral nitrogen resulted in a higher C_{org} content, in accordance with Haynes and Körschens (Haynes and Naidu, 1998; Körschens, 1997). The C_{org} content in system C increased by an average of 2.4 t/ha C_{org} to 6.5 t/ha C_{org}, which equals the 4.8-12.9 % rise compared to the average value of C_{org} content in AN0.

After 11 years, the C_{org} content in system A decreased - in the AN0 control by 4.6 t/ha C_{org} (8.6%), in AN3, where the mineral nitrogen was added, by 2.7 t/ha C_{org}, corresponding to 5.0%. Fertilization with the highest amount of mineral nitrogen resulted in a minor reduction of the C_{org} content compared to the AN0 control (Figure 2). The results suggest that the degree of mineralization in system A is greater than the degree of humification.

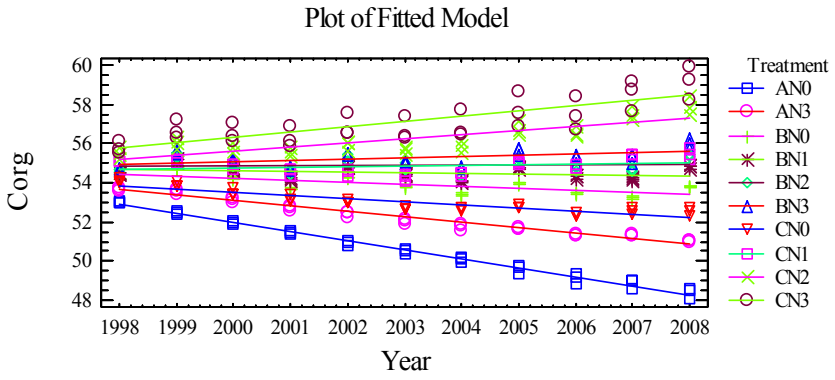

***Figure 2**: The C_{org} content (t/ha) in the period 1998-2008 for ten different treatments at the IOSDV Jable location.*

In system B, the C_{org} content in the treatment without the mineral nitrogen (BN0) decreased by 0.4 t/ha C_{org} (0.7%) compared to the initial value of the C_{org} content in the year 1998. By increasing the amount of mineral nitrogen, the C_{org} content rose by 0.4 t/ha C_{org} in BN1, by 0.8 t/ha C_{org} in BN2 and by 1.3 t/ha C_{org} in BN3. In comparison with the initial value in 1998, the C_{org} content in system C in 2008 was higher only in the treatments where mineral nitrogen was added; in CN1, the C_{org} content increased by 0.4 t/ha C_{org}, in CN2 by 2.5 t/ha C_{org} and in CN3 by 3.4 t/ha C_{org}.

Each year, the maximum C_{org} content was reached in the treatment CN3. The average value of difference of the C_{org} content between CN3 and AN0 throughout the eleven-year period was 6.6 t/ha C_{org}, varying from 2.7 t/ha C_{org} in 1998 to 10.6 t/ha C_{org} in 2008.

3.2 IOSDV Rakičan

Results for the C_{org} content at the IOSDV Rakičan location for the period 1998-2008 and the average C_{org} content for the eleven-year period are given in Table 4. The initial value of C_{org} in 1993 was 37.27 t/ha C_{org}. In the years studied (1998-2008), the impact of organic fertilization on the C_{org} content was confirmed. In system A, fertilizing with mineral nitrogen (AN3) increased the C_{org} content; the difference between treatments could, however, not be statistically confirmed. On average, the C_{org} content in AN3 increased to 35.47 t/ha, which is 2.8% more than the average value of the C_{org} content in the AN0 control.

In system B, the C_{org} content was, in all treatments, significantly higher compared to the AN0 control. Despite the differences in absolute values, we were unable to confirm statistically significant differences among treatments with a different degree of added mineral nitrogen (BN0, BN1, BN2, BN3). The C_{org} content in system B increased by an average of 4.1 t/ha C_{org} to 5.2 t/ha C_{org}, which was 11.9-15.1 % higher compared to the average value of C_{org} content in AN0.

In the straw ploughing in system (system C), the C_{org} content was higher in all treatments with regard to the C_{org} content in AN0. Fertilization with the lowest amount of mineral nitrogen (CN1) had insignificantly increased the C_{org} content in the years until 2005; from this year on, however, the impact was statistically significant. Among the treatments where medium (CN2) and the highest (CN3) amount of nitrogen was applied, there were no statistically significant differences. The C_{org} content in system C increased by an average of 3.8 t/ha C_{org} to 6.9 t/ha C_{org} compared to the average value of the C_{org} content in AN0, i.e. by 10.9% to 19.8%.

At IOSDV Rakičan, the C_{org} content in system A decreased after 11 years; in the AN0 control by 2.4 t/ha C_{org} (6.6 %), in AN3 where mineral nitrogen was added by 1.2 t/ha C_{org}, which equals to 3.4.0 %. These results are comparable to the results measured at IOSDV Jable (Figure 3). By increasing the amount of mineral nitrogen in system B, the C_{org} content increased by 3.5 t/ha C_{org} (BN1), by 4.1 t/ha C_{org} (BN2) and by 4.2 t/ha Corg (BN3). According to the C_{org} content in 1998 in system C, the C_{org} content increased in all treatments; in CN0 by 2.0 t/ha C_{org}, in CN1 by 4.0 t/ha C_{org}, in CN2 by 4.7 t/ha C_{org} and in CN3 by 5.6 t/ha C_{org}.

Each year, the maximum C_{org} content was reached in CN3. The average value of difference of the C_{org} content between CN3 and AN0 throughout the eleven-year period was 6.9 t/ha C_{org}, varying from 2.9 t/ha C_{org} in 1998 to 10.8 t/ha C_{org} in 2008

Table 4: *The C_{org} content (t/ha) during the period 1998-2008 and the average C_{org} content (t/ha) for the same period for ten treatments (including three different management systems: A, B, C and nitrogen fertilization: N0, N1, N2, N3) at IOSDV Rakičan at a depth of 0-25 cm, calculated by the "Swiss method".*

	IOSDV Rakičan C_{org} (t/ha)											
Trea.	**1998 Bar.**	**1999 Mai.**	**2000 Whe.**	**2001 Bar.**	**2002 Mai.**	**2003 Whe.**	**2004 Oats**	**2005 Mai.**	**2006 Whe.**	**2007 Oats**	**2008 Mai.**	**Aver 11yr.**
AN0	35.58 a ±0.18	35.40 a ±0.26	35.10 a ±0.28	34.78 a ±0.18	34.97 a ±0.47	34.62 a ±0.50	34.34 a ±0.54	34.17 a ±0.59	33.84 a ±0.61	33.46 a ±0.63	33.23 a ±0.72	34.50 a ±0.28
AN3	36.06 a	36.05 a	35.85 a	35.69 a	35.70 a	35.48 a	35.33 a	35.24 a	35.09 a	34.82 a	34.83 a	35.47 b
BN0	37.10 b	38.24 bc	37.89 bc	37.59 b	39.01 b	38.66 b	38.39 b	39.63 bc	39.34 bc	38.96 bc	40.1 bc	38.63 cd
BN1	37.39 b	38.68 cd	38.39 bcd	38.15 b	39.66 bc	39.31 bc	39.08 bc	40.3 bcd	40.06 bcd	39.74 bc	40.92 bcd	39.24 de
BN2	37.39 b	38.67 cd	38.40 bcd	38.21 b	39.86 bc	39.59 bc	39.40 bcd	40.74 cde	40.53 bcd	40.19 bcd	41.52 cd	39.49 e
BN3	37.56 b	38.89 cd	38.64 cde	38.48 b	40.02 bc	39.78 bc	39.57 bcd	40.94 cde	40.78 cd	40.45 bcd	41.74 cd	39.72 e
CN0	37.17 b	37.83 b	37.61 b	37.59 b	38.66 b	38.43 b	38.57 bc	38.83 b	38.61 b	38.48 b	39.19 b	38.26 c
CN1	37.67 b	38.48 bc	38.41 bcd	38.59 bc	39.98 bc	39.85 bc	40.18 cd	40.78 cde	40.83 cd	40.90 cd	41.64 cd	39.76 e
CN2	38.22 c	39.07 cd	39.15 ef	39.55 cd	40.70 cd	40.70 cd	41.02 de	41.75 de	41.93 de	42.09 de	42.92 de	40.65 f
CN3	38.49 c	39.35 d	39.44 f	39.98 d	41.52 d	41.56 d	41.86 e	42.61 e	42.88 e	43.07 e	44.12 e	41.35 f

*a-i – The same letter in the column indicates that there is no significant difference among treatments (Duncan multiple range test. p<0.05).

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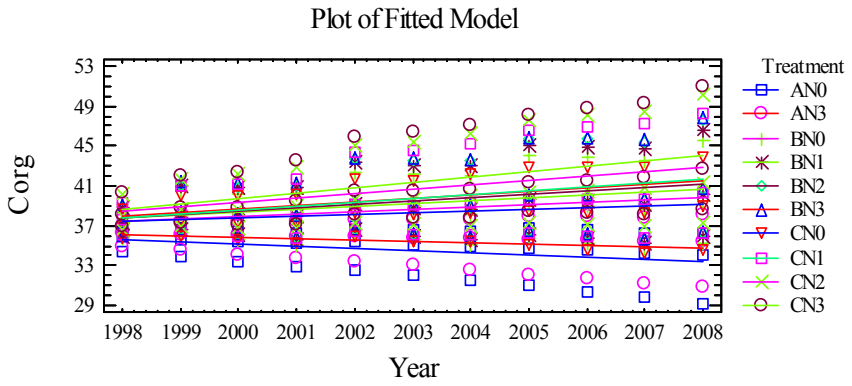

Figure 3: *The C_{org} content (t/ha) in the period 1998-2008 for ten different treatments at the IOSDV Rakičan location.*

According to Table 5, a greater influence of management systems and mineral N fertilization could be reached at IOSDV Rakičan. As the average absolute value of difference of the C_{org} content for all treatments amounted to 3.5 t/ha and was almost two times higher as at IOSDV Jable, it is possible to conclude that soil with a lower clay content could be more influenced by different management usage.

***Table 5**: Balance of C_{org} content during the eleven-year period (C_{org} in 2008 minus C_{org} in 1998) and the average absolute value of the C_{org} content (x_{aver}) (t/ha) at the IOSDV Jable and IOSDV Rakičan locations.*

	IOSDV Jable	**IOSDV Rakičan**
Treatment	$\|C_{org2008}-C_{org1998}\|$ (t/ha)	$\|C_{org2008}-C_{org1998}\|$ (t/ha)
AN0	|-4.6|	|-2.4|
AN3	|-2.7|	|-1.2|
BN0	|-0.4|	|3.0|
BN1	|0.4|	|3.5|
BN2	|0.8|	|4.1|
BN3	|1.3|	|4.2|
CN0	|-1.6|	|2.0|
CN1	|0.4|	|4.0|
CN2	|2.5|	|4.7|
CN3	|3.4|	|5.6|
X_{aver}	1.8	3.5

4 CONCLUSIONS

During eleven-year period the application of organic fertilizers in the form of farmyard manure or straw significantly influenced the C_{org} content at two long-term experiments, with different soil and climatic conditions. At IOSDV Jable, within system B, the C_{org} content increased by an average of 3.3 t/ha C_{org} to 4.7 t/ha C_{org} compared to the C_{org} content in the AN0 control. Moreover, in the system with ploughing in of straw and catch crops (system C), the C_{org} content also increased by an average of 2.4 t/ha C_{org} to 6.5 t/ha C_{org}. At IOSDV Rakičan, within system B, the C_{org} content increased by an average of 4.1 t/ha C_{org} to 5.1 t/ha C_{org} compared to the C_{org} content in the AN0 control, while, in system C, the C_{org} content increased by an average of 3.8 t/ha C_{org} to 6.8 t/ha C_{org}. A significant impact of mineral N on the C_{org} content was determined in systems A and C at both locations, while in system B this impact could not be proven.

After 11 years, the C_{org} content in system with no organic fertilizers (system A) decreased irrespective of the mineral N fertilization at both locations. At IOSDV Jable, a small decrease of the C_{org} content was measured in BN0, while all other treatments at IOSDV Jable and IOSDV Rakičan resulted in an enlarged C_{org} content. The average absolute value of difference between the C_{org} content in 2008 and 1998 for all treatments at IOSDV Rakičan was almost two times higher as at IOSDV Jable. According to these results as well as according to other authors´ statements we determined that soil with a smaller clay content shows the greatest dependence on the selected management.

5 ACKNOWLEDGEMENT

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6 REFERENCES

Angers, D.A., Carter, M.R. (1996): Aggregation and Organic Matter Storage in Cool, Humid Agricultural Soils. V: Structure and Organic Matter Storage in Agricultural Soils. Carter, M.R. and Stewart, B.A. (ur.). CRC Press, Boca Raton, pp. 193-211.

Bucur, D., Jitareanu, G., Ailincai, C., Tsadilas, C., Ailincăi, D., Mercus, A. (2007): Influence of soil erosion on water, soil, humus and nutrient losses in different crop systems in the Moldavian Plateau, Romania. Journal of Food, Agriculture & Environment, Vol. 5 (2): 261-264.

Campbell, C.A., McConkey, B.G., Zentner, R.P., Selles, F., Curtin, D. (1996): Long-term effects of tillage and crop rotations on soil organic C and total N in a clay soil in southwestern Saskatchewan. Canadian Journal of Soil Science, 76: 395-401.

Delschen, T. (1999): Impacts of long-term application of organic fertilizers on soil quality parameters in reclaimed loess soils of Rhineland lignite mining area. Plant and Soil, 213: 43-54.

Diez, T., Krauss, M. (1992): Berechnung von Humisbilanzen, SuB 06: III-9-III-11.

Edmeades, D.C. (2003): The long-term effects of manures and fertilisers on soil productivity and quality: a review. Nutrient Cycling in Agoecosystems, 66: 165-180.

Franko, U. (1997): Modellierung des Umsatzes der organischen Bodensubstanz. Archives of Agronomy and Soil Science, 41: 527-547.

Gerzabek, M.H., Pichlmayer, F., Kirchmann, H., Haberhauer, G. (1997): The response of soil organic matter to manure amendments in a long-term experiment at Ultuna, Sweden. European Journal of Soil Science, 48: 273-282.

Haynes, R.J., Naidu, R. (1998): Influence of lime, fertilizer and manure applications on soil organic matter content and soil physical conditions: a review. Nutrient Cycling in Agroecosystems, 51: 123-137.

Karlen, D.L., Ditzler, C.A., Andrews, S. S. (2003): Soil quality: why and how? Geoderma, 114: 145-156.

Kay, B.D., Angers, D.A. (1999): Soil Structure. V: Handbook of Soil Science. Sumner, M.E. (ur.). CRC press, Boca Raton, pp. A-229-A- 276.

Körschens, M. (1997): Abhängigkeit der Organischen Bodensustanz (OBS) von Standort und Bewirtschaftung sowie Ihr Einfluss auf Ertrag und Bodeneigenschaften. Archives of Agronomy and Soil Science, 41: 435-463.

Körschens, M., Schulz, E., Klimanek, E.-M., Franko, U. (1997): Die Organiche Bodensustanz - Bedeutung, Denifition, Bestimmung. Archives of Agronomy and Soil Science, 41: 427-433.

Körschens, M. (2001): How do organic fertiliser systems influence the C pool in long-term experiments? In: Applying compost benefits and needs. Seminar Proceedings, Brussels, 22-23 November, 2001; pp. 37-47.

Körschens, M. (2006): The importance of long-term field experiments for soil science and environmental research - a review. Plant Soil and Environment, 52, (Special Issue): 1-8.

Kristaponyte, I. (2005): Effect of fertilisation systems on the balance of plant nutrients and soil agrochemical properties. Agronomy Research, 3 (1): 45-54.

Martens, D.A., Frankenberger, W.T. Jr. (1992): Modification of Infiltration Rates in an Organic-Amanded Irrigated Soil. Agronomy Journal, 84: 707-717.

Nardi, S., Morari, F., Berti, A., Tosoni, M., Giardini, L. (2004): Soil organic matter properties after 40 years of different use of organic and mineral fertilisers. European Journal of Agronomy, 21: 357-367.

Ogle, S.M., Breidt, F.J., Paustian, K. (2005): Agricultural management impacts on soil organic carbon storage under moist and dry climatic conditions of temperate and tropical regions. Biogeochemistry, 72: 87-121.

Paustian, K., Collins, H.P., Paul, E.A. (1997): Management Controls on Soil Carbon. V: Soil Organic Matter in Temperate Agroecosystems. Paul, E.A., Elliott, E.T., Paustian, K., Cole, C.V. (ur.) CRC press, Boca Raton, pp.15-51.

Powlson, D.S., Smith, P., Coleman, K., Smith, J.U., Glendining, M.J., Körschens, M., Franko, U. (1998): A European network of long – term sites for studies on oil organic matter. Soil & Tillage Research, 47: 263-274.

Purakayastha, T.J., Rudrappa, L., Singh, D., Swarup, A., Bhadraray, S. (2008): Long-term impact of fertilizers on soil organic carbon pools and sequestration rates in maize-wheat-cowpea cropping system. Geoderma 144: 370-378.

Rasmussen, P.E., Goulding, K.W.T., Brown, J.R., Grace, P.R., Janzen, H.H., Körschens, M. (1998): Long-Term Agroecosystem Experiments: Assessing Agricultural Sustainability and Global Change. Science, 282: 893-896.

Reeves, D.W. (1997): The role of soil organic matter in maintaining soil quality in continuous cropping systems. Soil & Tillage Research, 43: 131-167.

Riley, H., Pommeresche, R., Eltun, R., Hansen, S., Korsaeth, A. (2008): Soil structure, organic matter and earthworm activity in a comparison of cropping systems with contrasting tillage, rotations, fertilizer levels and manure use. Agriculture, Ecosystems and Environment, 124: 275-284.

Shevtsova, L., Romanenkov, V., Sirotenko, O., Smith, P., Smith, J.U., Leech, P., Kanzyvaa, S., Rodionova, V. (2003): Effect of natural and agricultural factors on long-term soil organic matter dinamics in arable soddy-podzolic soils - modelling and observation. Geoderma, 116: 165-189.

Slepetiene, A., Slepetys, J. (2005): Status of humus in soil under various long-term tillages systems. Geoderma, 127: 207-215.

Shulz, F., Brock, C., Leithold, G. (2008): Effects of Farm Type and Different Intensities of Soil Tillage on Cash Crop Yields and Soil Organic Matter. In: 16th IFOAM Organic World Congress, Modena, Italy, June 16-20, 2008 (http://orgprints.org/11990)

Tajnšek, A. (2003): Vsebnost humusa in nekatere fizikalne lastnosti tal v odvisnosti od gnojenja z organskimi gnojili in dušikom v IOSDV Jable in IOSDV Rakičan. In: Deset let poskusov IOSDV v Sloveniji, Jable in Rakičan 1993-2003. Zbornik posveta. Tajnšek, A., Čeh Brežnik, B., Kocjan Ačko, D. (ur.) Ljubljana, pp. 25-34.

Zech, W., Senesi, N., Guggenberger, G., Kaiser, K., Lehmann, J., Miano, T.M., Miltner, A., Schroth, G. (1997): Factors controlling humification and mineralization of soil organic matter in the tropics. Geoderma, 79: 117-161.

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Agrovoc descriptors: aphidoidea; parasitoids; life cycle; natural enemies; biological control; plant protection

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Življenjski krog parazitoidov listnih uši

Katarina KOS[1], Stanislav TRDAN[2]

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IZVLEČEK

V prispevku je opisan življenjski oz. razvojni krog parazitoidov listnih uši, saj so ti naravni sovražniki pomembni dejavniki zmanjševanja številčnosti populacij škodljivih listnih uši v naravnih in kmetijskih ekosistemih. Posebna značilnost listnih uši je njihov biotični potencial, saj imajo lahko nekatere vrste pravih listnih uši (Aphididae) v enem letu tudi več kot 50 rodov (spolnih in nespolnih oz. partenogenetskih). Listne uši so ravno zaradi svojih izjemnih razmnoževalnih sposobnosti gospodarsko zelo pomembni škodljivci gojenih in samoniklih rastlin, zato jih želimo zatreti na različne načine. Z biotičnim varstvom rastlin skušamo oblikovati naravno ravnovesje med škodljivci in njihovimi naravnimi sovražniki ter s tem preprečiti močnejšo prerazmnožitev škodljivcev. Parazitoidi so pri svojem delu zelo učinkoviti, saj v končni stopnji razvoja ličinke svojega gostitelja vedno ubijejo, poleg tega pa so večinoma izraziti polifagi in tako niso specializirani za posamezne vrste gostiteljev.

Ključne besede: življenjski krog, parazitoidi listnih uši, naravni sovražniki, biotično varstvo rastlin

ABSTRACT

LIFE CYCLE OF APHID PARASITOIDS

The paper introduces the life cycle of aphid parasitoids, because they have an important role in reducing populations of aphids in natural and agricultural ecosystems. Special characteristics of aphids is their reproductive ability. Some species from Aphididae family can have more than 50 generations (sexual and asexual or parthenogenetic) per year and that makes them important pests of cultivated and wild-growing plants. That is why we want to suppress them in any possible way. With biological control we try to establish natural balance between pests and their natural enemies, and so prevent the increse in number of pests. Parasitoids are very effective, because in final stage of larva parasitoid always kills its host. Besides that, parasitoids are polyphagous insects and in most cases are not specialized just for one species.

Key words: life cycle, aphid parasitoids, natural enemies, biological control

1 UVOD

Paraziti ali zajedavci so entomofagne žuželke. Poseben tip parazitizma, ki se vedno konča s poginom gostitelja, izvajajo parazitoidi in ta tip parazitizma poznamo le pri žuželkah (Enemigos naturales, 1997). Parazitoidi so bolj specializirani. Na ali v enega gostitelja odložijo po eno ali več jajčec. Nekaj dni po parazitiranju se po obliki in barvi spremeni videz škodljivca. Iz škodljivca, ki pogine, izleti odrasla žival (parazitoid); pri nekaterih vrstah pa ličinka parazitoida že prej zapusti telo gostitelja in se zabubi zunaj njegovega telesa (pri nekaterih vrstah pod njim) (Milevoj, 1997).

Razvojni krog vseh parazitoidov je razdeljen na 4 stadije; jajčece, ličinko, bubo (pupo) in imago, zato jih uvrščamo v skupino holometabolnih žuželk ali žuželk s popolno preobrazbo (Godfray, 1994). Odrasli osebki parazitoidov so večinoma aktivni ob toplih, sončnih dnevih, še posebno v poznih jutranjih urah in popoldne. Kažejo torej pozitiven fototaktični odziv (Starý, 1988, cit po Minks in Harrewijn, 1988). Življenjska doba parazitoidov je različna. Jajčece lahko zori od 1 do 2 dni (tudi do 5 dni), stadij ličinke traja od 7 do 15 dni, stadij

[1] Teach. Assist., B. Sc., Jamnikarjeva 101, SI-1111 Ljubljana, e-mail: katarina.kos@bf.uni-lj.si

[2] Assoc. Prof., Ph. D., ibid.

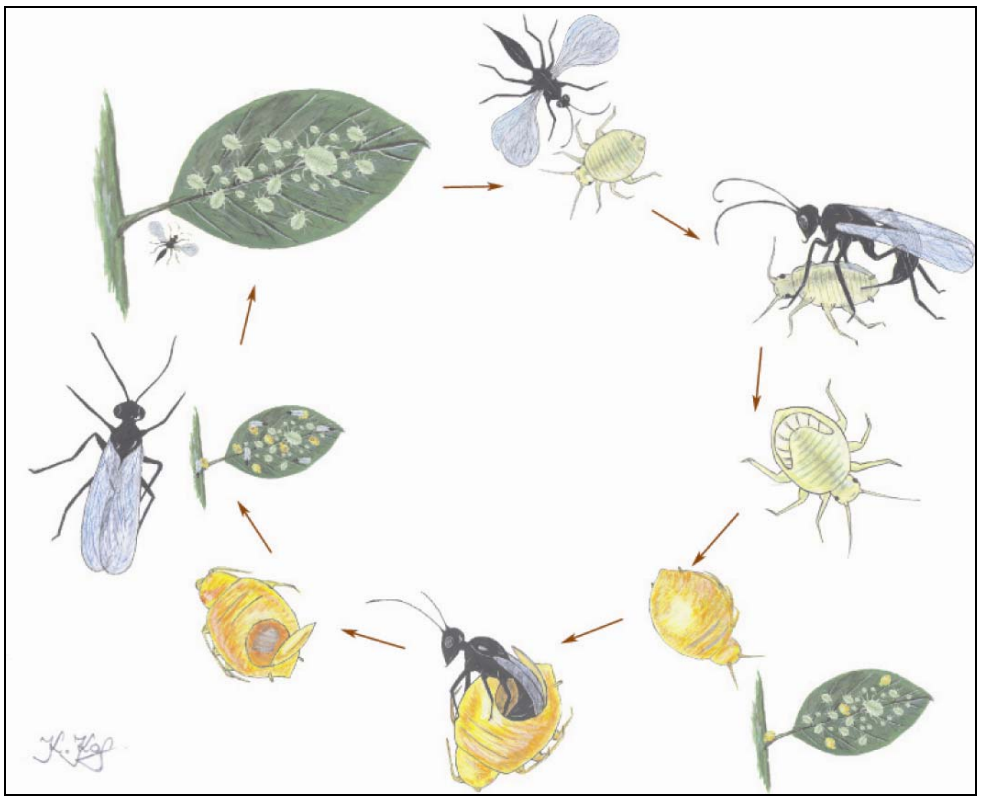
bube pa od 4 do 8 dni (tudi 10). (Cierniewska, 1976; Cloutier in sod., 1981, cit po Minks in Harrewijn, 1988).

Na prostem je v večini zgledov mogoče zaslediti več samic kot samcev, vendar pa je to odvisno od dejavnikov okolja. Razmnoževanje je večinoma biparentalno; iz neoplojenih (haploidnih) jajčec se razvijejo samci, iz oplojenih (diploidnih) jajčec pa samice (Minks in Harrewijn, 1988). Kljub biparentalnemu razmnoževanju parazitoidov, se moški potomci ne razvijejo le iz jajčec neoplojenih samic, ampak tudi iz samic, ki so se parile. Le-te lahko ležejo neoplojena jajčeca še nekaj ur po kopulaciji in tudi še na koncu njihove razmnoževalne linije, ko jim zaloge sperme že poidejo (Cloutier in sod., 1981, cit po Minks in Harrewijn, 1988). Uniparentalne vrste se razmnožujejo s partenogenezo. Ob tem se oblikuje veliko število samic in zelo malo samcev, pri nekaterih vrstah pa samcev sploh ni (Starý, 1970).

2 ŽIVLJENJSKI KROG PARAZITOIDOV LISTNIH UŠI IZ PODDRUŽINE APHIDIINAE

So majhne osice iz reda kožekrilcev (Hymenoptera). Odrasli osebki so veliki od enega do nekaj milimetrov, večinoma črni ali temno rjavi, z bolj ali manj rumenimi, oranžnimi ali rumenorjavimi vzorci. So specifični solitarni endofagni parazitoidi uši. V svetovnem merilu je znanih več kot 400 vrst iz 60 rodov in podrodov (Starý, 1970). Večino vrst najdemo v zmernem in subtropskem pasu severne poloble.

Pri iskanju ustreznega habitata pri parazitoidih imajo pomembno vlogo rastline, ki so prehrambeni vir za gostiteljsko vrsto uši, saj lahko vonj teh rastlin privabi tudi parazitoida. Imagi porabijo velik del življenja za iskanje okolja, kjer bi bil lahko zastopan potencialni gostitelj. Za to lahko uporabljajo vizualne, akustične ali vonjalne sposobnosti, pogosto je tudi zaznavanje vibracij zaradi premikanja gostitelja. Najbolj pomembne so vonjalne sposobnosti parazitoidov. Vizualne in akustične sposobnosti pogosto vodijo parazitoide do gostiteljev le na krajše razdalje, medtem ko imajo vonjalne sposobnosti pomen pri iskanju na mnogo večjih razdaljah in tudi še potem, ko gostitelj že zapusti rastlino (van Alphen in Jervis, 1996, cit. po Jervis in Kidd, 1996).



***Slika 1**: Razvojni krog parazitoida listnih uši (K. Kos).*

Sinovigene vrste, katerih jajčeca zorijo tudi v obdobju odraslosti, lahko prvih nekaj dni v stadiju odraslega osebka preživijo ob iskanju negostiteljske hrane, torej nektarja in medene rose, s čimer si zagotovijo zalogo za razvoj jajčec. Tako se lahko zgodi, da se mladi osebki ne odzivajo na vonjalne dražljaje gostiteljskih rastlin in gostiteljskih žuželk. Na nekatere parazitoide v zgodnem stadiju odraslega osebka lahko vonj deluje celo odvračalno, čeprav jim pozneje služi pri iskanju gostitelja (van Alphen in Jervis, 1996, cit. po Jervis in Kidd, 1996).

Ko parazitoid prispe v potencialni habitat gostitelja, prestopi v naslednji stadij iskanja gostitelja. Žuželke se pogosto odzivajo na kairomone z majhno intenziteto vonja, ki ostane za gostiteljih na substratu. Materiali, ki vsebujejo te kairomone, vključujejo izločke žlez slinavk ali mandibularnih žlez, medeno roso enakokrilcev in izločke kutikule (van Alphen in Jervis, 1996, cit. po Jervis in Kidd, 1996). Kairomoni gostitelja privlačijo parazitoida in tako povečajo možnost odkritja gostitelja. Lociranje gostitelja pa je odziv na nekemične, torej vizualne in čutilne dražljaje.

Na aktivnost iskanja gostitelja pomembno vpliva tudi gostota populacij uši in gostota populacij parazitoidov. Vizualni in tipalni dražljaji tipalk parazitoida ter gibanje uši imajo pri tem izredno pomembno vlogo (Starý, 1970).

Znano je, da se uši raje hranijo na mlajših listih, ki imajo večjo koncentracijo primarnih metabolitov (Merritt, 1996). Zato odrasli parazitoidi iščejo potencialne gostitelje večinoma na zgornjih delih rastlin; tam tudi največkrat najdemo mumificirane uši.

Za vzpodbuditev odziva parazitoida z ovipozicijo, ki sledi lociranju gostitelja, morajo biti prisotni specifični dražljaji gostitelja. Za številne parazitoide je pomemben prepoznavni znak velikost gostitelja, oblika gostitelja, gibanje gostitelja, zelo pomembno vlogo pa imajo tudi kairomoni. Sprejemljivost gostitelja za ovipozicijo parazitoidov je v veliki meri odvisna tudi od tega ali je gostitelj že parazitiran (van Alphen in Jervis, 1996, cit. po Jervis in Kidd, 1996).

Ob stiku samica uš preuči s tipalkami, da ugotovi ali se v gostitelju že nahaja kakšen parazit. Nato zadek potisne pod oprsje in med noge. Zatem leglico (ovipozitor) na zadku zabode v telo gostiteljske uši. Jajčece lahko odloži ob vsakem vbodu, lahko pa tudi ne. Trajanje ovipozicije je odvisno od vrste in lahko traja manj kot sekundo ali tudi do ene minute. Samica, ki odlaga jajčeca, lahko zazna že parazitirano uš in se s tem izogne superparazitizmu (Starý, 1988, cit. po Minks in Harrewijn, 1988), saj samice ob ovipoziciji zaznamujejo gostitelja s posebnim ovipozicijskim deterentom. Z njim odvrnejo druge samice, da bi odložile jajčeca v istega gostitelja (Milevoj, 1992).

Večinoma razlikujemo 4 stopnje ličink (larvalne stopnje), vendar poročajo tudi o drugačnem številu. Na ličinki 1. stopnje so jasno razločljivi telesni deli in nakazane mandibule, ki so kaudalne (na repnem delu [*cauda*]). Segmentacija v 2., 3. in 4. stopnji ličinke je manj razločna in le 4. stopnja ličinke ima razvite mandibule. Preden ličinka zaključi z razvojem, oblikuje kokon znotraj ali pod kožo uši in se zabubi. V tem stadiju koža uši otrdi in nastane značilna mumija (sliki 2 in 3). Mumija uši ima vlogo varovalnih celic, znotraj katerih ličinka parazitoida zaključi njen razvoj do odraslega osebka. Prepupalni in pupalni stadij ter stadij imaga parazitoida se oblikujejo v mumiji (Cloutier in sod., 1981, cit po Minks in Harrewijn, 1988). Imagi nato izletijo iz mumije skozi okrogle odprtine na zadku uši, ki ima pokrov in se zlahka predre. Pri večini vrst iz poddružine Aphidiinae je lahko ta odprtina kjerkoli na zadku (*abdomen*) uši, nekatere vrste pa specifično oblikujejo izhodno odprtino le na apikalnem delu zadka. Ravno izleteli parazitoidi potrebujejo le kratek čas, da spolno dozorijo. Samci v enakih razmerah navadno izletijo nekoliko pred samicami. Parjenje sledi kmalu po izletu in traja le nekaj sekund (Starý, 1988, cit po Minks in Harrewijn, 1988).

***Sliki 2 in 3**: Mumiji listnih uši (slika 2) in prazna mumija ter izleteli parazitoid (slika 3) (K. Kos).*

Razmnoževalna sposobnost samic variira in lahko doseže tudi do nekaj 100 jajčec na samico. Vendar pa vsa jajčeca niso uspešno odložena v ustreznega gostitelja, niti ni porabljena celotna zaloga jajčec. Zaloga jajčec variira tudi pri različnih osebkih iste vrste. V jejcevodu je prisotnih določeno število zrelih jajčec, ostala jajčeca pa nastajajo in zorijo pozneje v življenju samice. Med ovipozicijo obstajajo tudi obdobja počitka, ko je ovipozicija prekinjena (Starý, 1970; Cierniewska, 1976, cit. po Minks in Harrewijn, 1988).

Specifičen odziv gostitelja ob parazitiranju z nekaterimi vrstami parazitoidov se kaže v tem, da lahko parazitirane uši še pred mumifikacijo zapustijo kolonijo in se umaknejo v mikrohabitat, ki je mikroklimatsko ugodnejši za parazitoida. Ta lastnost je vrstno pogojena in se lahko razlikuje tudi med posameznimi rodovi iste vrste (Starý, 1970; Cierniewska, 1976, cit po Minks in Harrewijn, 1988). Grahova uš, ki so jo parazitirale vrste *Aphidius ervi* Haliday, *Aphidius pisivorus* Smith, *Monoctonus paulensis* (Ashmead) in *Praon pequodorum* Viereck se je mumificirala blizu območja hranjenja uši na fižolu, medtem ko so se uši iste vrste, parazitirane s strani parazitoida *Ephedrus californicus* Baker, umaknile in mumificirale zunaj kolonije uši in stran od območja hranjenja (Chow in Mackauer, 1999). Parazitirane uši se tako tik pred poginom in mumifikacijo umaknejo tja, kjer so parazitoidi v njih varnejši pred napadom hiperparazitoidov ali pa tako povečajo možnost njihovega preživetja med prezimovanjanjem (Brodeur in McNeil, 1992, cit. po Chow in Mackauer, 1999).

Gostitelji niso edini pogoj za uspešno razmnoževanje parazitoidov. Prav tako sta pomembna zavetje in hrana parazitoidov, pri čemer imajo pomembno vlogo tudi sosednje rastline, medsevki, pleveli idr. Parazitoidi morajo iskanje gostiteljev periodično prekinjati in si poiskati hrano, da ohranijo energijo, visoko plodnost in dolgo življenje (Takasu in Lewis, 1993; Jervis in Kidd, 1995; Sirot in Bernstein, 1996, cit. po Lewis in sod., 1998).

3 ZAKLJUČKI

Sposobnost razmnoževanja in preživetja parazitoida je odvisna predvsem od zmožnosti samice, da določi svojega potencialnega gostitelja (Al-Doghairi, 1994). Zelo velik pomen pri določanju vedenjskega vzorca parazitoidov pri iskanju gostitelja in ustreznega življenjskega okolja ima kemična komunikacija med žuželkami ter med žuželkami in rastlinami. Vsaka informacija pri interakciji med dvema individuuma ima kemično osnovo (Dicke in Sabelis, 1988, cit po Minks in Harrewijn, 1988). Večina parazitoidov se odziva na vonjalne kairomone ali sinomone za lociranje gostitelja na velike razdalje.

Parazitoid selektivno izrablja njegove gostitelje glede na različne parametre kakovosti. Ob izbiri med različnimi vrstami gostiteljev, parazitoidi težijo k hranjenju na vrstah, ki so šibkejše in so slabši gostitelj za razvoj parazitoida. Diskriminacija poteka tudi glede na velikost gostitelja, saj manjše gostitelje uporabijo za hranjenje, večje pa za ovipozicijo. Parazitoidi lahko razločijo tudi stopnjo razvoja gostitelja (Kidd in Jervis, 1991, cit. po van Lenteren, 2003) ali njegovo predhodno parazitiranost. Ko samica parazitira gostitelja, ga zaznamuje s feromoni. Tako ga prepozna druga samica iste vrste in sama vanj ne odloži jajčec.

Interakcija med ušmi in parazitoidi obstaja skozi vso rastno dobo. Parazitoid išče uši že kmalu po izletu iz mumije in tudi uši temeljnice so lahko parazitirane. Interakcija je lahko začasno prekinjena v vročih dnevih, ko je uši manj in parazitoidi stopijo v sezonsko diapavzo. Hibernacija ali prezimovalna diapavza je lahko prav tako naključna pri obeh udeležencih, čeprav v različnih razvojnih stadijih. Parazitoidi navadno vstopijo v diapavzo bolj zgodaj kot uši (Starý, 1988, cit. po Minks in Harrewijn, 1988). Število rodov parazitoidov v sezoni je odvisno od vremenskih razmer in od prilagoditve na življenjski krog gostitelja. Spremembe v prilagoditvi parazitoidov so možne celo znotraj populacije iste vrste, v istih ali različnih geografskih območjih (Starý, 1988, cit po Minks in Harrewijn, 1988).

Poznavanje življenjskega kroga parazitoidov listnih uši je izredno pomembno zaradi uvajanja parazitoidov kot agensov pri biotičnem varstvu rastlin pred škodljivci. Obenem pa moramo poznati tudi njihove gostitelje in gostiteljske rastline, ki so udeležene pri kemični komunikaciji med žuželkami in med žuželkami ter gostiteljskimi rastlinami.

4 ZAHVALA

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.5 VIRI

Al-Doghairi, M. 1994. The importance of plant allelochemicals in host location behavior of parasitoid insects. http://www.colostate.edu/Depts/Entomology/courses/en570/papers_1994/aldoghairi.html

Chow A., Mackauer M. 1999. Altered dispesal behaviour in parasitised aphids: parasitoid-mediated or pathology? Ecol. Entomol. 24: 276-283.

Enemigos naturales. 1997. Agroinfomación. http://www.infoagro.com/agricultura_ecologica/enemigosnaturales.asp (4.5.2007).

Godfray H.C.J. 1994. Parasitoids: Behavioural and Evolutionary Ecology. Princeton, New Jersey, Princeton University Press: 473 str.

Jervis M.A., Kidd N.A.C. 1996. Insect natural enemies. Practical approaches to their study and evaluation. London, Chapman and Hall: 504 str.

Merritt S.Z. 1996. Within-plant variation in concentrations of amino acids, sugar and sinigrin in phloem sap of black mustard, *Brassica nigra* (L.) Kock (Cruciferae). J. Chem. Ecol. 22: 1133-1145.

Milevoj L. 1992. Parazitoida *Aphidius matricariae* Hal. in *Diaeretiella rapae* M'Intosh (Hym., Aphidiidae) na *Rhopalosiphum padi* L. (Hom., Aphididae) v Sloveniji. Zb. Bioteh. fak. Univ. Ljubl. 59: 163-167.

Milevoj, L. 1997. Biotično varstvo rastlin/biotično zatiranje škodljivih organizmov (splošno), BF-agronomija. www.fito-info.bf.uni-lj.si/Fito2/ (2.5.2007).

Minks A.K. Harrewijn P. 1988. Aphids, their Biology, Natural Enemies and Control. World Crop Pests 2B. Amsterdam, Elsevier: 364 str.

Starý P. 1970. Biology of aphid parasitoids (Hymenoptera: Aphidiidae) with respect to integrated control. Series Entomologica, 6: 1-643.

van Lenteren, J.C. 2003. Quality Control and Production of Biological Control Agents: Theory and Testing Procedures. Wallingford, CABI Publishing: 327 pp.

Vinson S.B. 1975. Biochemical coevolution between parasitoids and their hosts. V: Evolutionary Strategies of Parasitic Insects and Mites. Price P.W. (ed) New York: Wiley: 224 str..

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Microoxygenation of red wines

Marko LESICA[1], Tatjana KOŠMERL[2]

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ABSTRACT

Microoxygenation is usually applied to red wines as a cheaper alternative to oak ageing. Utilization of wood cooperage for wine storage has several advantages. Among these are extractions of flavour and aroma active components, as well as controlled oxidative polymerization, a process commonly referred to as ageing. Although stainless steel tanks are, in the long term, less costly than cooperage, stored wines do not benefit from the features offered by wood. The process of microoxygenation in steel tanks utilizes controlled exposure of wines to oxygen provided by a sparger linked via a flow meter to a cylinder of oxygen. Oxygen flow rates vary over the course of treatment. During this period, different chemical reactions take place. For example, wine phenols (tannin precursors and anthocyanins) react to form polymeric species that enhance palate structure and colour stability in the wine. Oxygen also diminishes excessively green, herbaceous characters and reductive aroma of wine.

Key words: wine, microoxygenation, microoxy-genators, oxygen, phenols, colour, stability, anthocyanins, tannins, polymerization

IZVLEČEK

MIKROOKSIGENACIJA RDEČIH VIN

Mikrooksigenacija se načeloma uporablja pri rdečih vinih kot cenejša alternativna tehnika zorenja v lesenih sodih. Uporaba lesenih sodov ima določene prednosti. Med te štejemo ekstrakcijo aromatično aktivnih spojin, prav tako kontrolirano oksidativno polimerizacijo, proces poznan kot staranje oziroma zorenje. Cisterne iz nerjavnega jekla so v primerjavi z leseno posodo na dolgi rok dosti cenejše, vendar vina, zorena na tak način, niso deležna pozitivnih učinkov lesa. Za izvajanje procesa mikrooksigenacije v cisternah se poslužujemo aparature, ki omogoča dovajanje kisika v vino preko posebnega razpršilca, ki je vezan na dozirni bat. Količina dovedenega kisika se med procesom spreminja. Med tem potekajo številne kemijske reakcije. Na primer, fenoli (prekurzorji taninov in antocianini) reagirajo v procesu polimerizacije, pri čemer pride do povečanja fenolne strukture in stabilizacije barve. Kisik povzroči zmanjšanje prekomernega zelenega, vegetativnega značaja in reduktivnih arom vina.

Ključne besede: vino, mikrooksigenacija, mikrooksi-genatorji, kisik, fenoli, barva, stabilnost, antociani, tanini, polimerizacija

1 INTRODUCTION

High-quality red wines are traditionally stored for a long time in oak barrels to improve their sensorial attributes. Oak ageing leads to colour stabilization, lower astringency, and the disappearance of excess vegetative notes. These latter transformations seem to be associated with small quantities of oxygen that penetrate the porosity of wood, the interstices between staves, and bunghole. The process of microoxygenation aims to mimic the effects of slow barrel maturation within a shorter period and for less of the long-term cost associated with oak barrels.

[1] Univ. dipl. inž. živ. tehnol., Vinska klet »Goriška Brda« z.o.o. Dobrovo, Zadružna cesta 9, 5212 Dobrovo

[1] Doc. dr., Univerza v Ljubljani, Biotehniška fakulteta, Oddelek za živilstvo, Jamnikarjeva 101, 1000 Ljubljana

The purpose of micro-oxygenation is to bring about desirable changes in wine texture and aroma which cannot be obtained by traditional ageing techniques. The objectives of the process include improved mouthfeel (body and texture), enhanced colour stability, increased oxidative stability, and decreased vegetative aroma. As treatment proceeds, one eventually observes an augmentation of the aromatic intensity, a development of the complexity. The tannins are less hard and softer, the body of the wine is increased, and the wine's mouthfeel is rounder. The herbaceous aromas and the reduction character vanish and the length may increase.

Microoxygenation has been employed commercially in France as a wine treatment technique since 1991 when Patrick Ducournan began experimenting on the wines of Madiran in south-western France. The technique consists of continuously bubbling small amounts of oxygen in the wine, slower than the rate of consumption so that there is no accumulation of dissolved oxygen. Since its inception, the technique has commercially spread throughout the winegrowing world and is now systematically used in some wineries entire winemaking process, predominantly red wines.

2 OXYGEN IN WINE

2.1 Oxygen solubility

The dissolved oxygen concentration can be calculated by using a solubility coefficient, using Henry's law: $pO_2 = H \cdot C^*$, where H is the oxygen solubility coefficient and C* is the gaseous oxygen concentration at equilibrium. The oxygen solubility coefficient depends on temperature, pressure and the liquid composition.

Berta *et al*. (1999) report that wine is saturated with oxygen at 7.7 mg/L at 20 ºC. The oxygen solubility decrease as the ethanol content increase up to 30%, but beyond that ethanol content strongly increases the oxygen solubility. The oxygen solubility also depends on wine temperature, content of total dry extract, reducing sugars and carbon dioxide (Cheynier *et al*., 2002).

2.2 The role of oxygen during winemaking

Microoxygenation is a controlled technique, which aims to manipulate the rate and result of the oxygen-requiring reactions in wine in order to bring desirable changes in wine texture and aroma (Castellari *et al*., 2000; Atanasova *et al*., 2002, Cagnasso *et al*., 2003). This can be contrasted to the well-known and widely used practice of aerated racking which adds oxygen to the wine in large, discrete doses (Figure 1).

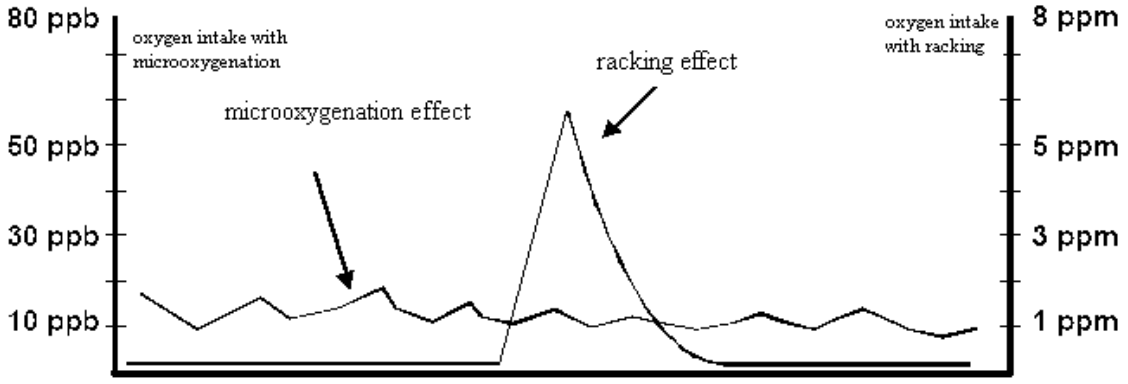

Figure 1: *Dissolving oxygen during microoxygenation and racking of wine (Cagnasso et al., 2003)*

For example, it has been estimated that ullage from proper barrel storage adds as much as 12 to 20 mL/L per year of oxygen to wines (Zoecklein, 2007). Therefore, allowing for several rackings, a total of around 30 mL/L could be added to red wine in barrel each year.

It has long been recognized that oxygen plays an important role in the numerous microbiological and biochemical events that take place during the life of a wine. These events not only facilitate the winemaking process but also ultimately affect the organoleptic characteristics of the finished wine (Morata *et al*., 2006).

During microoxygenation small, controlled amounts of oxygen (O_2) are bubbled into wine to bring about positive changes in the wine. This is achieved by filling a known volume with gas at a high pressure. The volume is then transferred via a low-pressure circuit to the diffuser and into the wine. The latter normally

consists of a ceramic or stainless steel sparger that produces small bubbles, which can dissolve in the wine (du Toit *et al*., 2006). The aim of microoxygenation is to introduce O_2 into the wine at a rate equal to or slightly less than the wine's ability to consume that O_2 to avoid too much O_2 build up in the wine. It has to be managed in such a way that, after addition, all O_2 has been used up, while sufficient SO_2 is still left to protect the wine against excessive oxidation and microbial spoilage (du Toit *et al*., 2006).

- During fermentation
  Oxygen is necessary for healthy and viable yeast cells. In particular, it promotes synthesis of sterols/fatty acids in yeast cell walls. It is generally accepted that there is little risk of oxidation during fermentation. However, some aromatic and delicate white wines such as Riesling and Sauvignon Blanc may lose some volatile compounds with over-enthusiastic oxygen sparging.
- For white wines
  Oxygen can interact with lees to increase the apparent weight and mouthfeel of wines, especially those stored in barrel. Oxygen can also promote browning of colour and the loss of positive aromatics.
- For red wines
  Much research and practical experimentations has shown the integral role of oxygen plays in the polymerization of polyphenolic compounds, especially in the early stages of maturation. Polymerizations can produce stable forms of anthocyanins that resist decolourisation by sulphur dioxide and provide better colour stability at wine pH. It can also result in coloured forms (pigment polymers) that are stable over time. On the other hand too much oxygen can help bring about the formation of large molecules with high molecular weight that are unable to stay in solution. This causes precipitation of polyphenolic material, leaving wines dry and harsh to the taste with reduced colour intensity.
- For improving aromatic profile
  Winemakers have found that repeated aerated rackings can diminish excessively green, herbaceous characters.
- For removing reductive characters
  Exposure to air, usually via racking, can help remove unpleasant reductive, sulphidic characters from wine (Parish *et al*., 2000; Goals …, 2001; Paul, 2002; Zoecklein, 2007)

3 EFFECT OF MICROOXYGENATION ON WINES

Microoxygenation has effect on fermentation development, ageing process, phenolic and volatile composition, colour and on the sensorial properties.

Oxygen plays an important role in the different process that take place during winemaking process and the ageing of wine. Besides, oxygen has an influence on the phenolic composition and indirectly, also has an effect on some sensorial characteristic, such as colour, aroma and astringency, all of which determine wine quality (Atanasova *et al*., 2002; Ortega Heras *et al*., 2008).

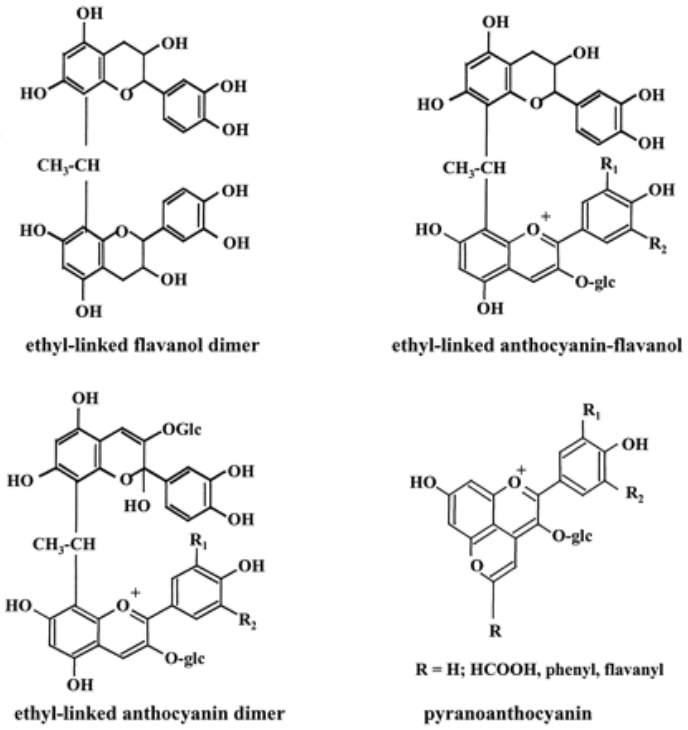

Figure 2: *Example of ethyl-linked phenols (Cheynier, 2005)*

Oxidation condensation and polymerization reactions in which different compounds are involved (mainly phenolic compounds) are oxygen dependent (Rivero-Pérez *et al*., 2008). These reactions lead to formation of new pigments and polymeric compounds that can stabilize wine colour and reduce astringency, as pyranoanthocyanins and ethyl-bridged adducts shown in Figure 2 (Ortega Heras *et al*., 2008).

The oxygen dissolution, by enhancing the condensation and polymerization reactions, influence on the content of some phenolic compounds such as catechin, epicatechin, ferulic acid, *p*-cumaric acid, quercetin, *trans*-resveratrol, caffeic acid and other (Castellari *et al*., 2000; Llaudy *et al*., 2006; Cano-López *et al*., 2006). Oxygen has also an effect on the volatile composition of wine. The addition of oxygen showed changes in the content of some esters, short chain fatty acids, terpenic compounds, hexanol, and other volatile compounds (Ortega Heras *et al*., 2008).

3.1 Oxygen consumption in wine

Oxygen consumption is much faster in red wines than in white wines, indicating that it is largely due to the oxidation of phenolic compounds. It is also accelerated at higher temperatures (Cheynier *et al*., 2002). Moutonet and Mazauric (2001) report that the consumption of oxygen in red wine saturated with oxygen takes 25 days at 13 ºC, 18 days at 17 ºC, 4 days at 20 ºC, 3 days at 30 ºC and just few minutes at 70 ºC. Wine lees have been shown to also contribute to oxygen uptake, thereby competing with phenolic compounds and impending the wine ageing process (Fornairon *et al*., 1999). The oxygen consumption capacity varies from 80 mg/L (in whites) to 800 mg/L (in reds) and thus much exceeds the optimum oxygen supply. An increase in pH and phenolic compounds enhances the consumption of oxygen. In general, the kinetics of oxygen dissolution in wine is much higher than its consumption. The more oxygen added, the more dramatic the results will be. Nowadays, tasting is the only way to evaluate the need of oxygen for a wine, and some correlations with analytical parameters such as total polyphenols, tannins and astringency are being studied (Pérez-Mangariño *et al*., 2007).

The amount of oxygen added is usually indicated as mL/L or mg/L. At 15 ºC 1 mg of oxygen is equal to 1.47 mL and at 20 ºC 1 mg of oxygen is equal to 1.5 mL (Nel, 2001).

3.2 Oxygen and polyphenol reactions

Oxygen stimulates different chemical reactions, especially polymerization of anthocyanins and tannins. This has the effect of reducing the amount of free anthocyanins and increasing the amount of condensed anthocyanins. Importantly, these condensed forms are generally coloured at wine pH (Atanasova *et al*., 2002; Paul, 2002). Oxidation reactions involving phenolic compounds are extremely complex processes that are

not fully elucidated. The major phenol compounds in young red wines are anthocyanins, the pigment of red grapes, and flavanols, which are encountered as monomers (catehins) and as oligomers or polymers (proanthocyanidins, also commonly called condensed tannins).

3.3 Chemistry of oxygen in wine

Phenolic reactions in wine generate modified tannins, degrade existing tannins, or generate new ones (Zoecklein, 2007; Ortega Heras *et al*., 2008). Wines are complex mixtures of grape phenolic compounds, usually grouped under the names anthocyanins and tannins, that can come from different sources: Colourful anthocyanins and less colourful procyanidins come from the grape skins, and harsh, even bitter, phenolics come from seeds, while odd-tasting, harsh phenolics come from stems. Polymerization and de-polymerization of tannins, and of tannins and anthocyanins, greatly impact their sensory characteristic. With oxygen exposure, several different structural linkages can create tannin polymerization. Polymerization reactions that occur between anthocyanins and tannins may generate stable compounds, which provide more colour intensity and are more resistant to degradation (Zoecklein, 2007).

Anthocyanins molecules have a positive charge. It increases the reactivity of the ring structure, which can lead to the destruction of the positive charge. This is countered by binding with tannin molecules, such as can occur with microoxygenation. The degree to which tannins and anthocyanins bind together is, in part, a function of the concentration of these molecules in solution. Anthocyanins and tannins bind together in two ways, depending upon the oxygen concentration (Ribéreau-Gayon *et al*., 2000). Under reductive conditions (low redox potencial), hydrolysis may break down a tannin molecule, producing two products, one charged molecule and one neutral molecule. Depending on the concentrations of tannins and monomeric anthocyanins, the charged molecule formed will react with one or the other. If it is tannin present, a longer oligomer or polymer will be form (Ribéreau-Gayon *et al*., 2000; Zoecklein, 2007).

However, the process differs if an anthocyanin is involved. An anthocyanin, in the hydrated or colourless form, provides an electron-rich molecule which more readily reacts with the charged tannin. The reaction occurs between the two molecules at the carbon-4 and carbon-8 positions, and a covalent bond is formed. Once formed, the larger tannin moiety acts as an electron sink and a stabilized colour or anthocyanin-tannin adduct is produced. The terminal molecule, the anthocyanin, no longer has available electrons in excess to further react, meaning that the anthocyanin acts as a terminus for any further reactions at this end of the polymer (Ribéreau-Gayon *et al*., 2000; Zoecklein, 2007).

The other tannin-anthocyanin reaction method involves oxidative polymerization. As such, acetaldehyde can play an important role in the formation of phenolic polymers in a wine and, thus, in microoxygenation. Acetaldehyde-bridged molecules (Figure 3) form to bind phenolic compounds together. These compounds are relatively stable and are somewhat resistant to bleaching by bisulphite ion (Ribéreau-Gayon *et al*., 2000; Zoecklein, 2007). Acetaldehyde bridging can also facilitate the formation of tannin-tannin complexes. Acetaldehyde linkages usually lead to C8-C8 bounding instead of C4-C8 (Cheynier *et al*., 2002). This can lead to different sensorial properties.

Acetaldehyde can be produced by yeasts during fermentation, can result from the coupled oxidation of ethanol by phenolics, and can be produced by adding toasted oak wood into a fermentor. The oxidation of ethanol to acetaldehyde occurs in the presence of O_2 at an appreciable rate (Wildenradt and Singleton, 1974). This coupled reaction involves the oxidation of a simple phenol (vicinal diphenol) to produce a coloured molecule (*ortho*-quinone). Hydrogen peroxide (H_2O_2) is produced as an intermediary of coupled oxidation. H_2O_2, a strong oxidant, then reacts with ethanol to form acetaldehyde. The newly-formed acetaldehyde can react with phenolics in a wine (Escribano-Bailón *et al*., 2001). Acetaldehyde forms a polymerization product between anthocyanins and tannins through an aldehyde bridge, for example. These can further react with other procyanidins or anthocyanidins, to form more complex trimers. However, it has been shown, that the compounds formed by ethyl bridges are unstable (Escribano-Bailón *et al*., 2001).

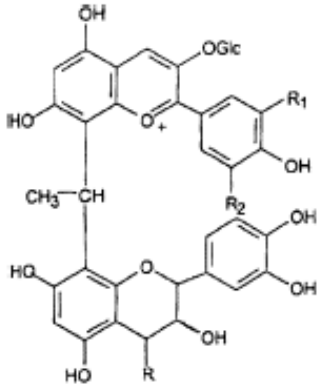

Figure 3: *Structure of pigments derived from the acetaldehyde-mediated condensation between anthocyanins and flavanols. R=flavanol units (Atanasova et al., 2002)*

Acetaldehyde also participates in the formation of new pigments such as vitisin B and other pyranoanthocyanins (Fulcrand *et al*., 1998; Mateus *et al*., 2002). Pyranoanthocyanins are not present in grapes but form during wine production via various condensation reactions (Morata *et al*., 2006). The molecules are named from the presence of a fourth pyrane (heteroaromatic) ring which forms during the condensation reaction. Pyranoanthocyanins have common spectral characteristics with absorption maxima of 495-520 nm that are lower than those of grape anthocyanins. They contribute to the red-orange colour wines developed during ageing. The presence of this fourth ring renders these pigments more stable than grape anthocyanins to discoloration by SO_2, and to colour loss due to high pH and oxidative degradation during fermentation (Bakker and Timberlake, 1997, Cano-López *et al*., 2006).

4 PHASES OF MICROOXYGENATION

Oxygen can be supplied during different stages of the winemaking process. The total dose can range from 60 mL/L for lighter whites, to 600 mL/L for tannic reds. It can be supplied at 1-5 mg/L/day for a few days just after malolactic fermentation, especially to press wine fractions that are rich in polyphenols (du Toit *et al*., 2006). The stage when microoxygenation is normally applied is during the ageing period after malolactic fermentation, when between 1-6 mg/L/month is introduced into the wine, although certain researchers recommended addition even up 10 mg/L/month (du Toit *et al*., 2006).

The wine's temperature must be around 15 ºC (Figure 4) because temperatures that are too high will lead to pour solubility of O_2 and temperatures that are low to chemical reactions taking place too slowly.

The best time to start the microoxygenation is when the alcoholic fermentation is complete with or without lees. Lees will take up oxygen, however, so far red wines it is more effective to rack off lees when practical or at least to be sure they are well settled (Goals …, 2001). We can divide microoxygenation into three phases:

- phase of structuration (before and after malolactic fermentation),
- phase of harmonization,
- phase of saturation – over oxygenation.

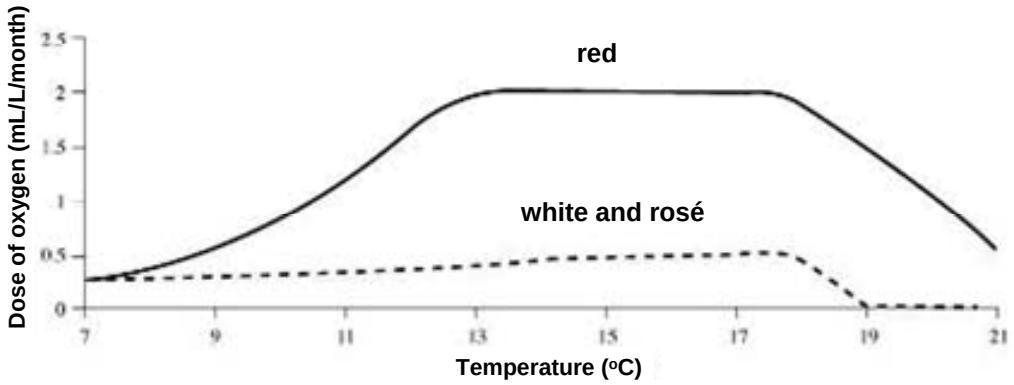

Figure 4: *Maximum amount of oxygen that may be added to wine at different temperatures (Nel, 2001)*

4.1 Phase of structuration

The initial phase is termed structuring and is characterised by the building of tannins or an apparent increase in the tannic structure of the wine. This phase is divided in two parts.

4.1.1 Prior to malolactic fermentation

Microoxygenation ideally begins directly after alcoholic fermentation and before malolactic fermentation, for two to six weeks, when colour stabilization occurs (Goals …, 2001; Parish *et al*., 2000). Getting started quickly is important because wine rapidly loses its ability to absorb O_2.

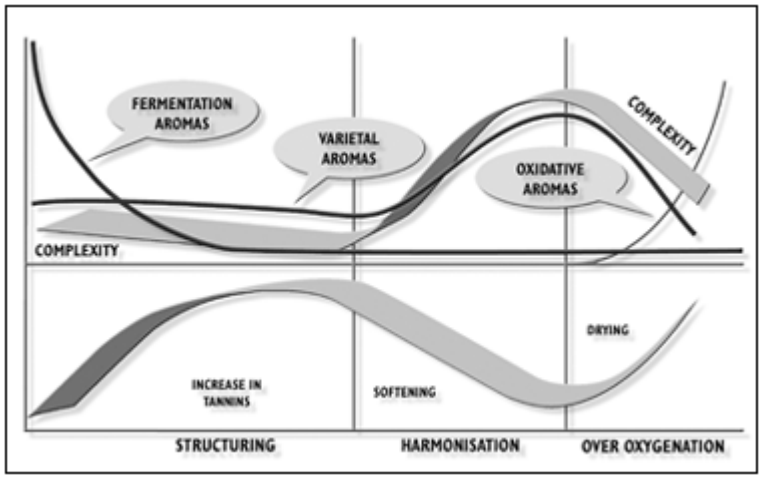

Figure 5: *The organoleptic phases observed in wine during the process of micro-oxygenation (Parish et al., 2000)*

Monomeric and oligomeric anthocyanins are more unstable in the early phase of wine maturation. The early addition of oxygen is intended to stimulate polymerization and increase colour stability. At this time the tannins are more susceptible to oxidation due to the lack of SO_2 (Paul, 2002). To delay malolactic fermentation, the use of lysozyme has been suggested. During this period, it is necessary to taste three times per week to adjust treatment based on several sensory clues. For example, acetaldehyde aroma in this phase should be present only at the level of a chocolate-like aroma, more than that indicates the level of O_2 should be turned down; hydrogen sulfide (H2S) and related reduced aromas indicate to raise the level of O_2.

The wine may also taste different because of the loss of CO_2 and green flavours when it is sparged with oxygen (Goals …, 2001; Parish *et al*., 2000). The most important sensory feedback concerns tannins (Figure 5). Wine tannins are classified in four ways: green, hard, soft and dry. The treatment moves tannin from green

through hard to soft, but not as far as dry (Zoecklein, 2007).

4.1.2 After malolactic fermentation and SO_2 addition
The second phase of structuration begins after malolactic fermentation and SO_2 addition. Dose rate is turned down about ten-fold, and tannin evolution continues (du Toit *et al*., 2006). Structuration potential depends on the initial structure of the wine. Wines high in tannins and low in anthocyanins risk dryness. High anthocyanins and low tannins indicate a low risk of dryness. High tannins and high anthocyanins make for the best situation, in which high oxygen levels may be used. Low tannins and low anthocyanins make for the most difficult winemaking (Goals …, 2001; Paul, 2002). Reactions are slower and less significant after sulphur dioxide addition because of its ability to bind with acetaldehyde and quench oxygen. SO_2 will readily bind to any free acetaldehyde, thus removing it as a reactant. In order to achieve the desired results from acetaldehyde-induced coupling, binding must occur before the wine is sulphited, or the free SO_2 level should be low (15 mg/L depending on pH) (Zoecklein, 2007). This usually means SO_2 additions are postponed until after microoxygenation is complete.

It may be difficult to differentiate between the normal hardening that occurs during this phase and a drying of the tannins. In this situation, a check on the SO_2 level, the evolution of the aromatic compounds, and the measure of the dissolved oxygen will enable you to determine if the process is occurring properly (Goals …, 2001; Parish *et al*., 2000). Tasting training on recognition and objective evaluation of types of tannins is a useful aid in following the wine and assessing the proper rate of addition. The temperature has a double impact on structuration. There is a direct influence on the speed of the reactions leading to the structuring effect. Also, oxygen solubility increases with decreasing temperature. Taken together, these effects present a danger to wines oxygenated at low temperature. If the temperature decreases, one must stop the process or at least limit the addition of oxygen, to avoid the accumulation of dissolved oxygen. Since this process usually takes place in winter, this situation occurs very frequently (Goals …, 2001).

4.2 Phase of harmonization
A harmonization phase follows the structuration phase. Once the period of tannin building has concluded, the harmonization stage is said to commence where the perceived tannic structure softens and the wine becomes more supple and approachable. The harmonization phase contrast with the structuration phase. The length of the harmonization phase is related to the structuration phase. It is the period of time going from the ageing to the bottling of the wine. The harmonization phase should generally be twice as long as the structuration phase, unless violent oxygenation (clique-age) is used to accelerate that period. We can call it the evolution phase of the wine, because the modifications occurring then are irreversible, as opposed to the first phase. Risks include the development of palate dryness, and excessive maturity accompanied by lost freshness and oxidized aromas (Goals …, 2001; Parish *et al*., 2000).

The dose of oxygen in this phase usually does not go over 1.0 mL/L/month (Goals …, 2001; Parish *et al*., 2000). The effects of the variation of the dose are more crucial than during the structuration phase. A variation in dose between 0.5 mL/L/month and 1.0 mL/L/month can produce a very different reaction in the wine. As the dose is very low during this phase, there is little risk of the accumulation of dissolved oxygen, so the temperature level is not very important. However, high temperature results in fast evolution and therefore increases the risk of oxidation (Goals …, 2001).

The ideal dose is determined by tasting, which looks for maximum aromatic benefit without causing dryness on the palate. As soon as the tannins begin to seem too dry, it is necessary to limit the oxygen or even to stop the microoxygenation. If microoxygenation is continued at this point, the result will be a wine that lacks in volume, becomes very flat, and the aromas of oxidation may appear irreversibly (Goals …, 2001; Parish *et al*., 2000). On the other hand, because the notion of hard tannins and dry tannins are very close, one can be confused. If the tannins are hard, it means that the wine needs some oxygen to soften them, and that the harmonization phase must continue. If the tannins are dry, it means the contribution of oxygen must be limited (Goals …, 2001). The goals of microoxygenation are to:
- establishing desired aromatic and taste qualities of the wine,
- developing aromatic complexity,
- improving the sensory qualities of tannins,
- stabilizing the wine from reductive flavours,
- diminishing some of the herbaceous flavours and any other remaining defects.

4.3 Phase of saturation
If a wine undergoes microoxygenation for too long then the tannins tend to dry out and become more astringent. This stage is termed over-oxygenation.

5 MONITORING OF THE PROCESS

Wine must be monitored during microxygenation. This can be time-consuming, especially in the pre-malolactic phase. Monitoring of the following parameters is suggested (Paul, 2002):

a) Dissolved oxygen: There should be no discernible increase in dissolved oxygen levels if microoxygenation is conduced properly, with an appropriate oxygen flow rate.
b) Free sulphur dioxide, if present: There should be no significant decrease in free sulphur dioxide levels during microoxygenation. However, it is important to understand that this does not mean the flow rate is correct; simply that it is not too high.
c) Temperature: This is an important and often misunderstood parameter. Microoxygenation works best between 14-17 ºC. If the temperature is too low, oxygen solubility is increased and reaction rates are decreased. This results in an increase of dissolved oxygen. If the temperature is too high, reactions occur more rapidly.
d) Turbidity: In general, wines should have some degree of clarification for successful microoxygenation. Wines should be below 200 NTUs (nephelometric turbidity units) and ideally below 100 (lees have a well-known affinity for oxygen). Of course, wines above these levels can be successfully treated, but more effort is required to monitor.
e) Tasting: Tasting microoxygenated wine is not intuitive. Some training and exposure to treated wines is valuable.

Acetic acid bacteria and *Brettanomyces* are both well-known spoilage microorganisms of wine. Both the organisms have been proven to grow in the wine when oxygen levels are increased (du Toit *et al*., 2006). Acetic acid bacteria can form elevated levels of acetic acid through the oxidative metabolism of ethanol. Oxygen could also stimulate the growth of *Brettanomyces*, but no direct link can be established with microoxygenation (Paul, 2002; du Toit *et al*., 2006). *Brettanomyces* can cause medicinal/barnyard characteristic in wine when oxygen levels are increased. If *Brettanomyces* grows in a microoxygenated wine, there may be other, more fundamental reasons for its proliferation, including high pH, low SO_2 and stressed fermentation amongst other. Winemakers contemplating microoxygenation need to understand the means for controlling *Brettanomyces* and make sure that they take the necessary precautions to minimize its impact (Paul, 2002; du Toit *et al*., 2006):

- If microoxygenating prior to malolactic fermentation ensure that no residual sugar is present in the wine. *Brettanomyces* loves sugar. Thus, a sluggish, difficult to ferment wine, may not be a good choice for microoxygenation unless the winemaker is absolutely sure of its status, both chemical and microbiological.
- Ensure prompt and stringent pH control.
- Add SO_2 at crushing (50 mg/L).
- Ensure sulphur dioxide levels in finished wines are adequate. Levels of 80 mg/L of total SO_2 have been quoted as inhibiting *Brettanomyces* growth.
- Do not microoxygenate at high temperatures.
- Do not microoxygenate wines made from unsound fruit. There is evidence that diseased fruit can considerably increase spoilage organism load.

6 CONCLUSIONS

Microoxygenation is a well defined process for improving wine quality. The chemistry underpinning the technique is not clearly understood at this stage, but the process is certainly developing. The effect of microoxygenation on a wine depends on the kind of wine (variety, origin, etc.) and the vintage. These facts can be related with the differences in the phenolic composition between grape varieties and therefore the doses of oxygen should be determined according to the initial phenolic composition of wines.

7 REFERENCES

Atanasova V., Fulcrand H., Cheynier V., Moutounet M. 2002. Effect of oxygenation on polyphenol changes in the course of wine-making. Analytica Chimica Acta, 458: 15-27.

Bakker J., Timberlake C. F. 1997. Isolation, identification and characterization of new color-stable anthocyanins occurring in some red wines. Journal of Agricultural and Food Chemistry, 45; 35-43.

Berta P., Spertino M., Vallini E. 1999. Ossigeno e imbottigliamento: Determinazioni sperimentali del tenore di ossigeno nei vini e tecnologie di riempimento. In: Ossigeno e vino. Giornata di studio, 19 marzo 1999, Piacenza. Chiriotti Editori; Istituto di Enologia e Ingenieria Alimentare. Piacenza, Università Cattolica del Sacro Cuore: 31-40.

Cano-López M., Pardo-Minguez F., López-Roca J. M., Gómez-Plaza E. 2006. Effect of microoxygenation on anthocyanin and derived pigment content and chromatic characteristics of red wines. American Journal of Enology and Viticulture, 57, 3: 325-331.

Cagnasso E., Gerbi V., Caudana A. 2003. Miglioramento della qualita dei vini rossi: valutazione della matuurita fenolica eapplicazione della microssigenazione. Agricoltura e Qualità, 36: 32-36.

Castellari M., Matricardi L., Arfelli G., Galassi S., Amati A., 2000. Level of single bioactive phenolics in red wine as a function of the oxygen supplied during storage. Food Chemistry, 69: 61-67.

Cheynier V. 2005. Polyphenols in foods are more complex than often thought. American Journal of Clinical Nutrition, 81,1: 223-229.

Cheynier V., Atanasova V., Fulcrand H., Mazauric., Moutounet M. 2002. Oxygen in wine and its role in phenolic reactions during ageing. In: Use of gases in winemaking. Proceedings of Seminar held in Adelaide. 10 October 2002, Adelaide. Allen M., Bell S., Rowe N., Wall G. (eds.). Adelaide, Australian Society of Viticulture and Oenology: 23-27

du Toit W. J., Lisjak K., Marais J., du Toit M. 2006. The effect of micro-oxygenation on the phenolic composition, quality and aerobic wine-spoilage microorganisms of different South African red wines. South African Journal of Enology and Viticulture, 27, 1: 57-67.

Escribano-Bailón T., Alvarez-garcia M., Rivas-Gonzalo J. C., Heredia F. J., Santos-Buelga C. 2001. Color and stability of pigments derived from acetaldehyde mediated condensation between malvidine 3-o-glucoside and (+)-catehine. Journal of Agricultural and Food Chemistry, 49: 1213-1217.

Fornairon C., Mazauric J. P., Salmon J. M., Moutounet M 1999. Observations sur la consummations de l'oxygène pendant l'élevage des vins. Journal International des Sciences de la Vigne et du Vin, 33: 79-86.

Fulcrand H., Benabdeljalil C., Rigaud J., Cheynier V., Moutounet M. 1998. A new class of wine pigments generated by reaction between pyruvic acid and grape anthocyanins. Phytochemistry, 47: 1401-1407.

Goals of micro-oxygenation. 2001. Sebastopol, Vivovation. (August 2001) http://www.vinovation.com/ MOotheory.htm (16. apr. 2005): 18 str.

Llaudy M. C., Canals R., González-Manzano S., Canals J. M., Santos-Buelga C., Zamora F. 2006. Influence of micro-oxygenation treatment before oak ageing on phenolic compounds composition, astringency, and color of red wines. Journal of Agricultural and Food Chemistry, 54, 4246 -4252.

Mateus N., Silva A. M., Rivas-Gonzalo J., Santos-Buelga C., de Freitas V. 2002. Identification of anthocyanin-flavanol pigments in red wines by NMR and mass spectrometry. Journal of Agricultural and Food Chemistry, 50: 2110-2116.

Morata A., Calderón F., González M. C., Gómez-Cordovés M. C., Suárez J. A. 2006. Formation of the higly stable pyranoanthocyanins (vitisin A and B) in red wines by the addition of pyruvic acid and acetaldehyde. Food Chemistry, 100: 1144-1152.

Moutounet M., Mazauric J. P. 2001. L'oxygene dissous dans les vins. Revue Français d'Oenologue, 186 : 12-15.

Nel L. 2001. The use of micro-oxygenation technique. Wynboer: A Technical Guide for Wine Producers, Suider Paarl http://www.wynboer.co.za/recentarticles/ 0101technique.php3 (22. apr. 2005): 4 str.

Ortega-Heras M., Rivero- Pérez M. D., Pérez-Mangariño S., González-Huerta C., González-Sanjosé M. L. 2008. Changes in the volatile composition of red wines during ageing in oak barrels due to microoxygenation treatment applied before malolactic fermentation. European Food Research and Technology, 226: 1485-1493.

Parish M., Wolan D., Paul R. 2000. Micro-oxygenation – a review. The Australian Grapegrower & Winemaker, 438a: 47-50. http://www.newworldwinemaker.com/ article.asp?mode=Archive&ID (25. apr. 2005)

Paul R 2002. Micro-oxygenation – where now? In: Use of gases in winemaking. Proceedings of Seminar held in Adelaide. 10 October 2002, Adelaide. Allen M., Bell S., Rowe N., Wall G. (eds.). Adelaide, Australian Society of Viticulture and Oenology: 18-22.

Pérez-Mangariño S., Sánchez-Iglesias M., Ortega-Heras M., González-Huerta C., González-Sanjosé M. L. 2007. Colour stabilization of red wines by microoxygenation treatment before malolactic fermentation. Food Chemistry, 101: 881-893.

Ribéreau-Gayon P., Glories Y., Maujean A., Duburdieu D. 2000. Handbook of enology. Volume 2. The chemistry of wine stabilization and treatments. Chichester, John Wiley & Sons: 353-393.

Rivero-Perez M. D., Gonzales-Sanjose M. L., Muniz P., Perez-Mangarino S. 2008. Antioxidant profile of red-single variety wines microoxygenated before malolactic fermentation. Food Chemistry, 111: 1004-1011.

Wildenradt H. L., Singleton V. L. 1974. The production of aldehydes as a result of oxidation of polyphenolic compounds and its relation to wine ageing. American Journal of Enology and Viticulture, 25, 2: 119-126.

Zoecklein B. W. 2007. Micro-oxygenation, current theory and applications. Practical Winery & Wineyard, november/december 2007: 24-32.

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Hordeetum murini Libbert**, 1932 – A ruderal association in Kosovo**

Qazim PAJAZITAJ[1]

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ABSTRACT

The paper deals with the vegetation of the association *Hordeetum murini* Libbert 1932 (*Sisymbrietalia*, *Sisymbrion*) in Kosovo. It is one of six ruderal communities studied in Kosovo during 1988 – 1991. The association *Hordeetum murini* is a ruderal vegetation that appears later in the spring and disappear in the beginning of the summer. This association is well developed in all habitats of Kosovo. This paper deals with the floristic and syntaxonomic analysis of association (Table 1), which encapsulates 12 relevés out of 62 species. It was also analyzed the biological spectrum of association, and symbols of life forms of each species. Also, in the analysis of floral geoelements, groups of these elements have been determined and presented by its spectrum.

Key words: *Hordeum murinum,* ruderal, community, syntaxonomy, Kosovo.

Hordeetum murini Libbert**, 1932 – RUDERALNA ASSOCIACIJA NA KOSOVU**

IZVLEČEK

Članek obravnava vegetacijo asociacije *Hordeetum murini* Libbert, 1932 (*Sisymbrietalia, Sisymbrion*) na Kosovu. Asociacija je ena izmed šestih znanih ruderalnih združb na Kosovu. Tovrstne združbe so bile na Kosovu preučevane med letoma 1988 in 1991, vendar uspevanje obravnavane asociacije *Hordeetum murini*, na tem območju, do sedaj ni bilo znano, in je v tem članku tako prvič obravnavana. To je ruderalna vegetacija, ki se optimalno razvije pozno pomladi in se posuši na začetku poletja. Omenjena asociacija je dobro razvita v vseh predelih Kosova. Floristična sestava asociacije, ki je predstavljena z 12 vegetacijskimi popisi, je razvidna iz analitične fitocenološke tabele (Tabela 1), v kateri je skupno 62 vrst rastlin. Analiziran je tudi biološki spekter življenjskih oblik. Poleg tega, je bila za asociacijo narejena analiza in spekter flornih geoelementov, pri čemer so bile vrste uvrščene v 13 skupin geoelementov.

Ključne besede: *Hordeum murinum*, ruderalen, združba, sintaksonomija, Kosovo.

1 INTRODUCTION

The research of flora and vegetation in Kosovo, undertaken so far, are indicating their richness and their relative abundance. In these researches are incorporated almost all types of vegetation, starting from the vegetation of hilly-forests in Kosovo (Krasniqi, 1972), vegetation of pasture ground communities, vegetation of lower meadows, vegetation of segetal plants (Kojić, Pejčinović, 1982). However, one part of this vegetation, particularly the ruderal one, has not been researched until recently.

In Southeast Europe there have been researches done also on ruderal vegetation. The first studies were done by Oberdorfer. As per the data given by Markovic (1978) we can say that the research on ruderal vegetation has been done in different parts of the Balkan peninsula, such as in Vojvodina (Slavnić)), in Croatia (Horvat, Horvatić, Marković, 1965, 1969, 1975, 1979, 1980, 1984, 1987,). In regards to other areas there are known researches of Aichinger, Oberdorfer, Slavnić, Lakušić, Tomić-Stanković, Trinajstić. Later on this

[1] Corresponding author: University of Prishtina, Faculty of Mathematics and Natural Sciences, Department of Biology, Phone: ++38 138 549 872, Mobile: ++377 44 103 168, E-mail: qpajazitaj@gmail.com.

vegetation was researched also in Macedonia (Matvejeva, 1982).

The relief of Kosovo was formed during the Orogenic phase. The mountains appeared above water during Miocene, whereas ponds, valleys, Fushë-Kosova, during Pliocene. The region of Kosovo represents an important link of the south-eastern branch of Alpine range (Dinaric-Albanic-Hellenic mountain range). Within a small territory one can discern a variety of geological formations of different ages, from the Precambrian to the Quaternary periods (Meçaj 1999).

As far as the climate is concerned, Kosovo belongs to the Mediterranean, with a slight influence of the continental climate. Moreover, in the Fushë-Kosova plain one can notice a small influence of the steppe climate. So Kosova in general has wet, relatively short and cold at winter, whereas summers are hot and relatively dry. The average year air temperature revolves from 9.5^{0}C (Prishtina) to 12 ^{0}C (Prizren). The average yearly rains revolve from 600 mm/year in the eastern region to 900 mm/year in the western ones (Peja and Gjakova), and over 1.500 mm/year in the Bjeshkët e Namuna (Krutaj 1999).

Viewed from its horizontal position, vegetation in Kosovo belongs mainly to the Euro-Siberian vegetative region. According to Horvatić (1967:31), the hot valleys of the low parts of Kosovo belong to the Aegean province. The highest part of Kosovo belongs to the Moesic province, whereas smaller part in North-West belongs to the Illyrian one. The highest zones belong to the Nordic-Alpic region. Therefore, Kosovo is a cross-road of influences of three phyto-geographical regions.
In Kosovo about 2.400 species of vascular flora have been established (Pajazitaj 2004). If we have in mind that in the Balkans there are approximately 6.800 vascular species, then we can conclude that the flora of Kosovo represents around 35% of this flora. The flora of Kosovo appears to be even more interesting because of the participation of approximately 200 endemic and relict species. Even though the surface of its territory represents 2.3% of the Balkans, the endemic and relicts species represent 11% of these plants within the Balkan Peninsula (Sala 1999).

2 MATERIAL AND METHODS

Ruderal vegetation was investigated according to the principles of the Zürich-Montpellier School. The scientific names of plants were coordinated with Forstner & Hűbl (1971). The species were also analyzed according to biological forms taken from Horvat (1949). The floral geoelements were determined according to Horvat, Glavač, Ellenberg (1974), and Forstner &Hübl (1971) and Flora of Albania (1988-2000).

3 RESULTS AND DISCUSSION

Association *Hordeetum murini* belongs to the alliance *Sisymbrion*, order of *Sisymbrietalia* and class of *Chenopodietea*.

This ruderal community develops almost exclusively beside roads, streets, and more rarely also in places that have been stepped on near houses and apartments, particularly in the outskirts of cities or big settlements. The development of this community begins during the month May and continues until the beginning of summer.

The floristic composition of this ruderal community is shown in the analytical table (Table 1), which include 12 relevés which were done in these localities of Kosovo, while the investigated area are presented in the map of Kosovo (Fig.1).

The characteristic species of the association in the researched area of Kosovo can be discerned: *Hordeum murinum L.,* as a dominant one, which has also a high level of presence (Tab.1)

***Tab.1**. Analytical table of association Hordeetum murini Libbert 1932*

Life forms	Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	Presence
	Surface (in m^2)	30	10	30	30	40	15	60	20	40	6	30	15	
	Cover (in %)	90	100	90	100	100	100	100	100	100	100	100	90	
	Number of species	26	19	19	17	17	15	15	15	14	14	14	11	
	ASSOCIATION CHARACTERISTIC SPECIES													
H	Hordeum murinum L.	3.3	3.3	2.3	4.4	3.3	4.4	5.4	4.4	5.4	4.3	4.4	3.3	V
	CHARACTERISTIC SPECIES OF SISYMBRION AND SISYMBRIETALIA													
T	Sisymbrium officinale (L.) Scop.	1.1	.	1.1	.	.	.	.	1.2	.	.	1.1	.	II
T	Lactuca serriola Tomer	+.1	.	.	+.1	.	.	.	.	+.1	1.1	.	.	II
T	Bromus tectorum L.	.	+.2	.	.	.	.	.	.	.	.	.	.	I
	CHARACTERISTIC SPECIES OF CHENOPODIETEA													
T	Capsella bursa-pastoris (L.) Med.	+.1	.	+.2	+.1	+.1	.	+.2	1.2	.	1.1	.	+.2	IV
H	Carduus acanthoides L.	1.1	2.1	1.1	1.1	1.1	1.1	1.1	.	.	1.1	.	.	IV
T	Bromus sterilis L.	+.2	.	.	.	+.2	+.2	+.2	.	.	.	.	+.2	III
H	Onopordum acanthium L.	1.1	.	1.1	1.1	.	.	.	1.1	.	.	.	.	II
H	Malva sylvestris L.	.	.	1.2	.	1.2	.	.	.	.	1.2	1.2	.	II
H	Cardaria draba (L.)Desv.	+.1	.	.	2.2	.	.	1.1	.	.	.	.	1.1	II
T	Sonchus oleraceus L.	.	.	.	.	+.1	.	.	.	.	.	.	.	I
	OTHER SPECIES													
H	Lolium perenne L.	+.2	+.2	+.2	.	1.2	+.2	.	1.2	+.2	+.2	+.2	+.2	V
H	Poa pratensis L.	+.2	+.2	+.2	.	+.2	+.2	+.2	.	+.2	.	+.2	.	IV
H	Arctium lappa L.	.	.	1.1	.	.	1.1	.	.	1.1	.	1.1	1.1	III
H	Rumex crispus L.	.	1.1	1.1	.	.	1.1	1.1	.	.	.	.	1.1	III
H	Taraxacum officinale Web	+.1	.	1.1	.	1.1.	.	+.1	.	+.1	.	1.1	.	III
G	Convolvulus arvensis L.	+.1	+.2	.	1.2	.	+.2	+.2	+.2	.	.	+.2	.	III
H	Dactylis glomerata L.	+.1	+.2	.	.	.	.	1.2	.	+.2	.	+.2	+.2	III
T	Bromus mollis L.	+.2	+.2	+.2	+.2	.	+.1	.	.	.	+.2	.	.	III
H	Lolium multiflorum Lam.	+.2	+.2	+.2	+.2	.	.	.	.	+.2	.	.	.	III
H	Cardaria draba (L.)Desv.	+.1	.	.	2.2	.	.	1.1	.	.	.	.	1.1	II
H	Conium maculatum L.	.	.	.	.	.	.	2.1	+.1	.	1.2	.	1.2	II
H	Plantago major L.	.	.	.	.	2.1	.	.	+.1	1.1	.	.	.	II
H	Ballota nigra L.	1.2	.	.	.	2.2	.	1.2	.	.	.	.	.	II
H	Achillea millefolium L.	.	1.1	.	1.2	.	1.2	.	.	.	.	.	.	II
H	Artemisia vulgaris L.	.	.	.	.	.	.	1.2	.	.	.	1.2	+.1	II
H	Cichorium intybus L.	.	.	.	+.1	1.1	1.1	.	.	.	.	.	.	II
H	Plantago lanceolata L.	.	.	.	.	.	+.1	.	.	+.2	1.1	.	.	II
H	Tripleurospermum inodorum Schulz-Bip	+.1	1.1	.	.	+.1	.	.	.	.	.	.	.	II
T	Anthemis austriaca Jacq.	1.2	+.1	.	+.2	.	.	.	.	.	.	.	.	II
H	Trifolium repens L.	+.2	.	+.2	.	.	.	.	.	+.2	+.2	.	.	II
T	Matricaria chamomilla L.	.	.	+.2	.	+.2	.	.	.	+.2	.	.	+.2	II
H	Trifolium pratense L.	+.2	.	+.2	.	.	.	.	.	+.2	.	+.2	.	II
T	Bromus arvensis L.	+.2	+.2	.	.	.	+.2	.	.	.	.	.	.	II
H	Polygonum aviculare agg.L.	.	.	+.2	.	.	.	+.2	+.2	.	.	.	.	II
T	Erodium cicutarium (L.) L`Her.	+.2	+.1	.	.	.	+.1	.	.	.	.	.	.	II
H	Anchusa officinalis L.	.	.	1.1	.	.	.	.	.	.	1.2	.	.	I
H	Cirsium arvense (L.) Scop.	.	.	+.1	.	.	.	1.1	.	.	.	.	.	I
T	Consolida regalis S.F.Gay.	1.1	+.1	.	.	.	.	.	.	.	.	.	.	I
T	Medicago lupulina L.	.	.	.	.	+.2	.	.	.	.	.	+.2	.	I
H	Silene vulgaris (Mnch.)Garcke	.	.	.	.	.	.	.	+.2	.	+.1	.	.	I
T	Torilis arvensis (Huds.)Link.	.	.	.	+.1	.	.	.	.	.	.	+.1	.	I
H	Poa trivialis L.	.	.	.	.	+.2	.	.	.	+.2	.	.	.	I

Less common species: 1. *Artemisia absinthium* L. 1.1, 2. *Rumex obtusifolius* L. 1.1; 3. *Berteroa incana* (L.) DC. 1.1; 4. *Tragopogon orientalis* L. 1.1; 5. *Atriplex tatarica* L. 1.1; 6. *Poa silvicola* Guss. +.2; 7. *Festuca pratensis* Huds. +.2; 8. *Bromus inermis* Leyss. +.2; 9. *Arrhenatherum elatius* (L.)Presl. +.2; 10.*Agropyron repens* (L.) P.B.+.2, 11. *Galium tricornum* Dandy +.2, 12. *Poa annua* L. +.2, 13. *Alopecurus myosuroides* Huds. +.2, 14. *Atriplex oblongifolia* W.et K. +.1, 15. *Geranium pusillum* L. +.1, 16. *Potentila inclinata* Vill. +.1, 17. *Anthemis arvensis* L. +.1, 18. *Haynaldia villosa* (L.) Schur. +.1, 19. *Eryngium campestre* L. +.1, 20. *Tragopogon* dubius Scop. +.1.

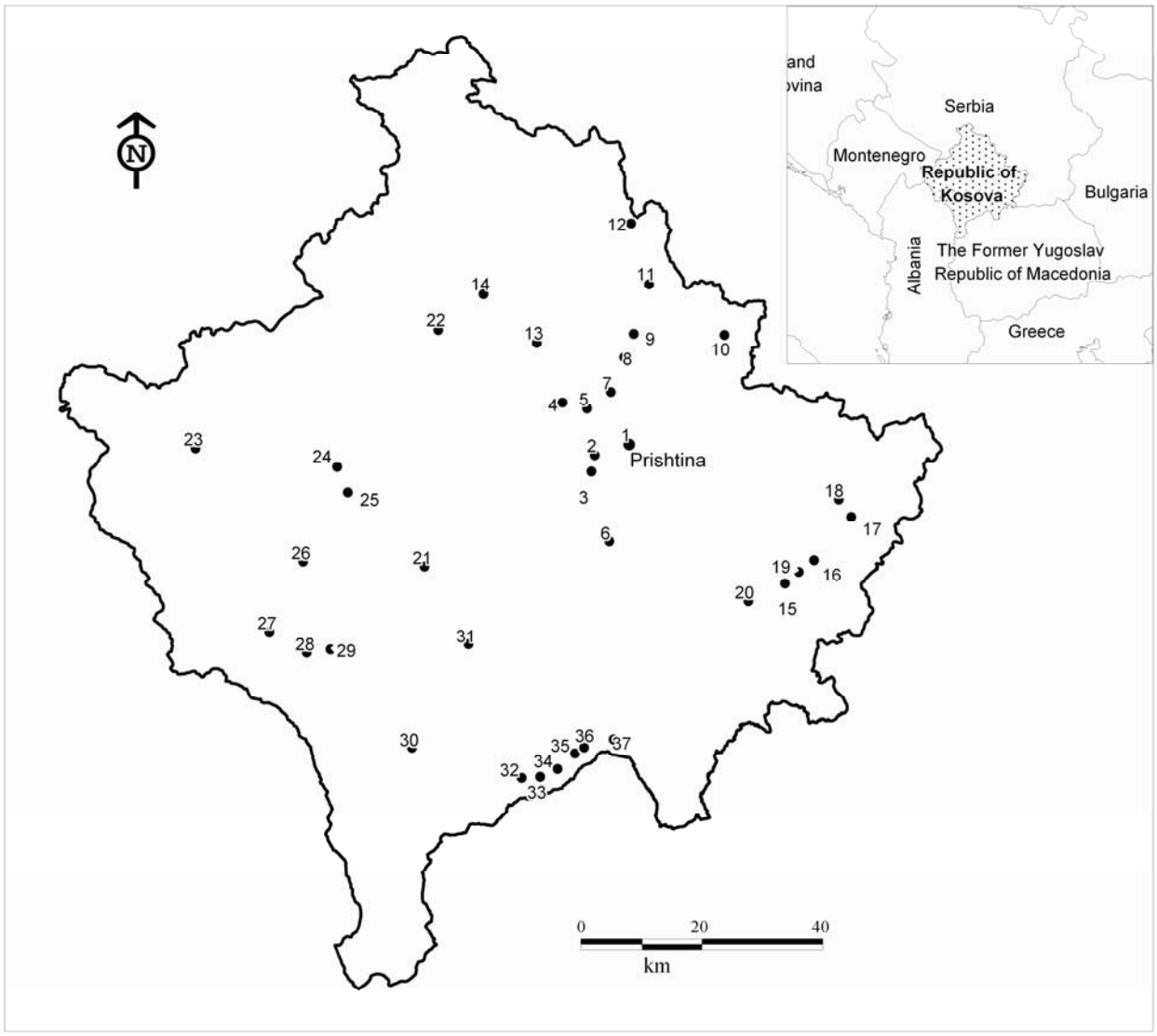

***Fig.1**. Localities in Kosovo where the investigated have been registered are as follows: **1** Gjilan - beside the road at the entrance of the city towards Prishtina, on a surface slightly turned towards the south, (12.VI.1990), **2**. Klina, beside the road which connects this settlement with the Prishtina – Peja motorway (10.VI.1990), **3**. Suhareka, near the main road at the centre of the settlement, **4**. Fushë-Kosova, near the main road at the outskirts of the settlement towards Prishtina (6.VI.1990). **5**,**7**,**12**, Prishtina, near the roads in the outskirts of city, (20,25, 30.VI 1990), **6**. Kamenica, near the road at the entrance of the settlement, on a slightly skewed surface, turned towards the east (12.VI.1990), **8**, **11**, Podujeva, beside the road of settlement (7.VI.1990), **9**, Peja, beside the road, in the city centre (10.VI.1990), **10**. Kerpimeh (Podujeva), near the wall of an inhabited house at the centre of the village (7.VI.1990).*

In Croatia (Marković-Gospodarić, 1965) as specific species of association *Hordeetum murini* are regarded: *Hordeum murinum*, *Malva silvestris* and *Bromus sterilis* whereas in Macedonia (Matvejeva,1982) distinguishes only *Hordeum murinum*. Also, in Croatia, (Marković-Gospodarić,1965) within the notes association two sub-associations are differentiated (*Arctium minus-Tripleurospermum inodorum* and normal), whereas in Macedonia (Matvejeva,1982) there are no sub-associations.

Having in mind floral composition of the investigated associations in Croatia, and in Macedonia, I`m of the opinion that the association *Hordeetum murini* which was investigated in Kosovo, belongs primarily to the ruderal association of the Sub-Mediterranean type. This is proven by the number of species (about 60), which is

nearly the same in both associations (in Kosovo and Macedonia), whereas in regard to the investigated association in Croatia it appears to be closer to ruderal associations of Central Europe. This is evident from the number of the species (121), and localities where relevés was carried out (mainly in the vicinity of Zagreb) (Marković-Gospodarić,1965:100-101).

In general, this community includes a relatively big number of species be that of a certain class or other ones, some of which have a high level of presence, such as *Capsella bursa-pastoris* (L.) Med.,*Carduus acanthoides* L., *Lolium perenne L.* and *Poa pratensis* L. The general number of species of such a community is relatively big (62), but a small number of them have two of the highest levels of presence (8%). The number of species in relevés revolves from 26 to 11, which in average is 16 species for each relevé.

As part of the association *Herdeetum murini*, several sub-associations have been described in the territory of Europe. The individuums of this association in the researched area of Kosovo can be attached to the sub-association *Hordeetum murini typicum* Tx.et Siss., 1942.

The development of this community begins at the end of April, continues during the month of May, while it reaches the optimum of its development in the first half of June. At the beginning of summer the drying up of the dominant species begins (*Hordeum murinum*), and it continues with the development of other hemicryptophyes, and some of them even develop towards the end of summer (for example *Atriplex tatarica, Chenopodium sp.* etc.).

The individuums of this association develop on dry surfaces, which are warm and exposed to the sun, and which are under the influence of three anthopozoogen factors: non-intensive stepping, insufficient fertilization and grazing, and non-intensive mowing respectively. This community normally does not develop in shadowy places. The community can develop for several years under the influence of these factors. On the contrary, it can recede very quickly and be replaced by the increasingly dominant hemicryptophytes, which contributes to the formation of the community of the association *Tanaceto-Artemisietum* (Markovic, 1965:102). It must be noted that on this occasion, in the researched area we have not followed the syn-dynamics of this community.

The biological specter of species of this association, which is calculated from the phytogeographical table, is as per below: Therophytes – 25 species or 40.32%, Hemicryptophytes 35 species or 56.45% and Geophytes 2 species or 3.23% As it can be seen, hemicryptophytes are dominant, followed by therophytes whilst the number of geophytes is minimal.(Tab.2).

Tab.2 *Biological spectrum of life forms*

Life forms	Number of taxa	%
H	35	56.45
T	25	40.32
G	2	3.23
Total	62	100.00

The floristic composition of the association of *Hordeetum murini* belongs to 13 geo-floristic elements. Below are presented the species of every floral geoelements group: **European-Asiatic species**: *Achillea millefolium*, *Arctium lappa*, *Artemisia absinthium*, *Atriplex tatarica*, *Bromus inermis*, *Bromus tectorum*, *Cardaria draba*, *Cirsium arvense, Conium maculatum, Dactylis glomerata, Festuca pratensis, Matricaria recutita, Medicago lupulina, Onopordum acanthium, Plantago lanceolata, Plantago major, Poa trivialis, Polygonum aviculare, Potentilla inclinata, Rumex crispus, Silene vulgaris, Sonchus oleraceus, Taraxacum officinale, Tragopogon orientalis, Trifolium pretense,. Trifolium repens, Tripleurospermum inodorum*; **Sub-Mediterranean species**: *Alopecurus myosuroides, Ballota nigra, Bromus sterilis*, *Galium tricornatum, Hordeum murinum, Lolium multiflorum, Torilis arvensis, Tragopogon dubius;* **European-Asiatic Sub-Mediterranean species:** *Bromus arvensis, Bromus mollis, Consolida regalis, Geranium pusillum, Lactuca serriola, Malva sylvestris, Sisymbrium officinale;* **Cosmopolitan species**: *Capsella bursa-pastoris, Cichorium intybus, Convolvulus arvensis, Lolium perenne, Poa annua, Poa pratensis*; **Central European species**: *Anthemis austriaca, Carduus acanthoides*; **Circumpolar species**: *Agropyron repens, Artemisia vulgaris*; **Euro-Asiatic Mediterranean species:** *Anthemis arvensis, Erodium cicutarium*; **Sub-Mediterranean Sub-Atlantic species** *Arrhenatherum elatius, Rumex obtusifolium*; **South-European species**: *Haynaldia villosa, Poa silvicola*; **Pontic species**: *Anchusa officinalis*; **Sub-Mediterranean-Pontic species**: *Berteroa incana*; **Continental species**: *Atriplex oblongifolia*; **Pontic-Mediterranean species**: *Eryngium campestre*.

The spectrum of floral geoelements of 62 species confirms these percentages: European-Asiatic (27 species or 43.54%), Sub-Mediterranean (8 species or 12.90%,), European-Asiatic–Sub-Mediterranean (7 species or 11.29%), Cosmopolitan (6 species or 9.67%), Central-European (2 species or 3.22%), South-European (2 species or 3.22%), Circumpolar (2 species or 3.22%),Sub-Mediterranean-Sub-Atlantic (2 species or 3.22%) and European-Asiatic-Mediterranean (2 species

or 3.22%) while the other geoelementes has only one species such as Pontic, Pontic-Mediterranean, Sub-Mediterranean-Pontic and Continental (Fig.2).

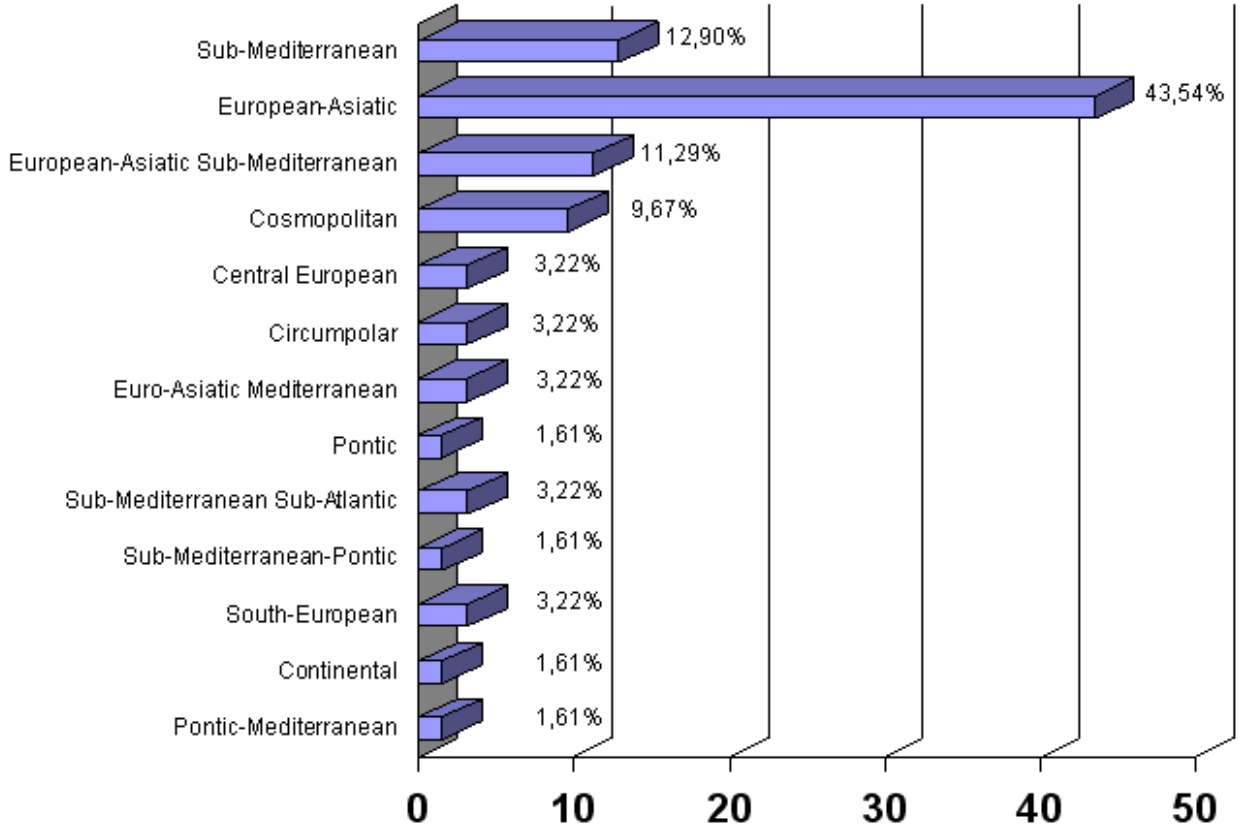

Fig. 2. *Spectrum of floral geoelements*

The individuums of this association are spread across the whole areas which were researched, with an almost exclusive concentration on the peripheral parts of cities and densely populated areas.

4 CONCLUSIONS

In this study we have presented the results of the fitocenological research of the ruderal community *Hordeetum murini* in Kosovo. This ruderal community, similar to the other ones belonging to this vegetation, was not researched nor known in the territory of Kosovo. The association *Hordeetum murini* Libbert 1932, belongs to the alliance *Sisymbrion*, order *Sisymbrietalia*, and class *Chenopodiatea*. The floristic composition of the community is presented in the analytical table which contains 12 relevés from different localities of Kosova.

Characteristic species of the association in the researched territory is: *Hordeum murinum* L..This ruderal community is characterized with a relatively big number of species (62), out of which hemicryptophytes are dominant (35 species or 56.45 %) and therophytes (25 species or 40.32 %), while only two species was assessed as a geophytes (2 species or 3.23 %). Out of the geofloristic elements 13 groups have been differentiated, out of which the biggest number belongs to the European-Asiatic one (27 species), Sub-Mediterranean (8 species), Euro-Asiatic-Sub-Mediterranean (7 species), Cosmopolitan (6 species), and the other groups have a small number of species (2 or 1 species).

5 REFERENCES

Forstner, W. und Erich Hűbl, 1971: Ruderal-Segetal und Adventivflora von Wien. Verlag Notring, Wien.

Horvat, I., 1949: Nauka o biljnim zajednicama. Nakladni zavod Hrvatske, Zagreb.

Horvat, I., V. Glavać, H. Ellenberg, 1974: Vegetation Sudosteuropas. Geobotanica Selecta, Band IV. Gustav Fischer Verlag, Stuttgart.

Horvatić, S.,1967: Fitogeografske značajke i raščlanjenje Jugoslavije. Analitička Flora Jugoslavije. Svezak prvi. broj 1.Zagreb.

Kojić, M., Pejčinović, D., 1982: Korovska flora i vegetacija Kosova. Posebna izdanja. Zavod za Udzb. i nast. sredstava SAP Kosovo. Priština.

Krasnići, F., 1972: Šumska vegetacija brdskog regijona Kosova. Priština.

Krutaj, F., 1999: Kosova në vështrim enciklopedik. Akademia e Shkencave, Qendra e enciklopedisë shqiptare.Tiranë.

Marković, Lj., 1969: O rasprostranjenju i sastavu asocijacije Sclerochloëtum durae Br.-Bl. 1931 u Hrvatskoj. Acta Botanica Croatica, Vol.XXVIII. Zagreb.

Marković, Lj.,1979: Das Sclerochloo-Polygonetum avicularis in der trittvegetation Nordostkroatiens. Acta Bot. Croat.vol.38,87-94. Zagreb.

Marković, Lj., 1987: Das Urtico-Aegopodietum in Nordwestkroatien. Acta Bot. Croat. 46, 73-79. Zagreb.

Marković, Lj., 1978: Übersicht der Ruderal pflanzengesell-schaften in Jugoslawien. Acta botanica Slovaca. Acad. Sci. Sovaceae, ser. A, 3.

Marković, Lj.,1980: Zajednica Polygono-Chenopodietum Lohm.1950 u vegetaciji sprudova rijeke Save u Hrvatskoj. Acta Bot. Croat. Vol.39,121-130. Zagreb.

Marković, Lj.,1984: Ruderalna vegetacija Gorskog Kotara. Acta.Bot. Croat.,43. 257-272.Zagreb.

Marković, Lj., 1975: O vegetaciji sveze Bidention tripartite u Hrvatskoj. Acta Bot. Croat. 34, 103-120. Zagreb.

Marković-Gospodarić, Lj., 1965: Prilog poznavanju ruderalne vegetacije kontinentalnih dijelova Hrvatske. Acta Botanica Croatica, Vol.XXIV,Zagreb.

kontinentalnih dijelova Hrvatske. Acta botanica Croatica, Vol. XXIV. Zagreb.

Matvejeva, J., 1982: Ruderalna vegetacija na SR Makedonija. Makedonska Akademija na naukite i umetnostite, Skopje.

Meçaj, N., 1999: Kosova në vështrim enciklopedik. Akademia e Shkencave, Qendra e enciklopedisë shqiptare.Tiranë.

Pajazitaj, Q.,2000: Hulumtimet fitocenologjike të vegjetacionit ruderal të Kosovës. Disertacion i dokto-ratures (manuscript). Prishtinë.

Pajazitaj, Q.,2004: Përcaktuesi i bimëve. Pteridofite&Spermatofite. Prishtinë

Paparisto, K., et al.,1988-2000: Flora e Shqiperisë (Flora de l`Albanie). I-IV. Akademia e Shkencave të Shqiperisë. Tiranë.

Sala, S.,1999: Kosova në vështrim enciklopedik. Akademia e Shkencave, Qendra e enciklopedisë shqiptare.Tiranë.

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Agrovoc descriptors: *Tetranychus urticae*; colonizing ability; *Chrysanthemum*; irrigation; leaves; trichomes; air; humidity; temperature

Agris category code: H10; F40; F06

Vpliv nekaterih dejavnikov na naselitev navadne pršice (*Tetranychus urticae* Koch) na krizanteme *Chrysanthemum* 'Veria Dark ' in 'Cassablanca White'

Mojca REMIC[1], Lea MILEVOJ[2], Marina PINTAR[3]

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IZVLEČEK

Raziskava nekaterih dejavnikov (temperatura zraka, relativna zračna vlaga, načini namakanja in gostota nežleznih dlačic) v povezavi z naselitvijo navadne pršice (*Tetranychus urticae* Koch) na krizanteme *Chrysanthemum* 'Veria Dark' in 'Cassablanca White' je potekala v letih 2003 in 2004 v rastlinjaku in v laboratorijih na Biotehniški fakulteti (Ljubljana). Krizanteme obeh sort so bile vzgojene iz sadik s koreninsko grudico. Tehnologija gojenja krizantem je bila v skladu s priporočili stroke in na podlagi lastnih opazovanj. Namakanje je bilo leta 2003 kapljično in poplavno, leta 2004 pa samo poplavno. Na naselitev navadne pršice na preučevani sorti krizantem vpliva način naselitve in poraščenost listov z nežleznimi dlačicami. Na razvoj navadne pršice vplivata temperatura zraka in relativna zračna vlaga. Prevelika količina vode v substratu pa negativno vpliva na kondicijo krizantem.

Ključne besede: *Tetranychus urticae*; navadna pršica; *Chrysanthemum*; krizanteme; namakanje; listne dlačice

ABSTRACT

INFLUENCE OF SOME FACTORS ON COLONIZATION OF TWOSPOTTED SPIDER MITE (*Tetranychus urticae* Koch) ON CHRYSANTHEMUM *Chrysanthemum* 'VERIA DARK' AND 'CASSABLANCA WHITE'

The research on factors (air temperature, relative air humidity, technology of irrigation, density of non-glandular trichomes) which influence the colonisation of twospotted spider mite (*Tetranychus urticae* Koch) on *Chrysanthemum* 'Veria Dark' and 'Cassablanca White' was carried out in 2003 and 2004 in greenhouses and in laboratories of the Biotechnical Faculty (Ljubljana). Both chrysanthemums were grown from seedlings with root clods. The technology of chrysanthemum growing was carried out according to professional recommendations and our own observations. Drop irrigation and flood irrigation were used. We found out that colonization of twospotted spider mite depends on the type of colonization and the density of leaf non-glandular trichomes. In both varieties of chrysanthemum, colonization and procreation of twospotted spider mite are influenced by air temperature and relative atmospheric humidity. Excess of water in the substrate have negative effect on chrysanthemums condition.

Key words: *Tetranychus urticae*; twospotted spider mite; *Chrysanthemum*; chrysanthemum; irrigation; leaf trichome

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This article is based on M.Sc. Thesis of Mojca Remic. Supervisor: Prof. Ph. D. Lea Milevoj, co-supervisor: Prof. Ph.D. Marina Pintar.

[1] mag., univ. dipl. inž. agr., Biotehniška fakulteta, Oddelek za agronomijo, Jamnikarjeva 101, SI-1111 Ljubljana

[2] prof., dr., Biotehniška fakulteta, Oddelek za agronomijo, Jamnikarjeva 101, SI-1111 Ljubljana

[3] izr. prof., dr., Biotehniška fakulteta, Oddelek za agronomijo, Jamnikarjeva 101, SI-1111 Ljubljana

1 UVOD

Navadna pršica (*Tetranychus urticae* Koch) napada več kot 200 (Sket in sod., 2003), po navedbah Zhanga (2003) pa več kot 300 rastlinskih vrst. Janežič (1975) jo je pri nas našel na 63-ih vrstah rastlin, vendar ne na krizantemah, na katerih se vse bolj pojavlja, predvsem v rastlinjakih. Škodljivost navadne pršice povečujejo dobra prehrana rastlin, zlasti z dušikom, raba insekticidov s širokim spektrom delovanja, ki prizadenejo njene naravne sovražnike, pa tudi sorazmerno hiter pojav odpornih osebkov pršice, na akaricide in insekticide (Vrabl, 1992). V rastlinjakih jo vzpodbujajo še visoke temperature, nizka relativna zračna vlaga, prepih in plevel, če raste ob obrobju rastlinjaka, kjer se pršice najprej naselijo (Lamparter, 1992).

Pri načrtovanju namakanja rastlin moramo upoštevati, da večje količine vode vzpodbujajo bolezni in škodljivce, ki potrebujejo za svoj razvoj bolj vlažne razmere. Poleg količine vode sta pomembna tudi čas in tehnika namakanja. S pravilno izbiro namakanja zmanjšamo relativno zračno vlago in omočenost rastlin. Če je v okolju več vlage, so rastline bolj sočne, bujne in bolj dovzetne za nekatere škodljive organizme. Povečana vlaga pospešuje razvoj patogenov. Nekatere spore kalijo že v kapljici rose. V mokrih tleh se nekateri paraziti hitreje in lažje gibljejo. Voda je potrebna tudi za izleganje ličink iz jajčec in za nadaljnji razvoj žuželk (Milevoj, 2003). Različni načini zalivanja (kapljično, poplavno) različno vplivajo na zračno vlago, ki je pomembna za razvoj pršic. Optimalne razmere za razvoj navadne pršice so: relativna zračna vlaga od 45 do 55 %, temperatura zraka od 30°C do 32°C in veliko svetlobe, pri čemer traja njen razvoj od 8 do 12 dni (Maceljski in sod., 1997). Pomembna je še starost rastlin in njihova občutljivost oziroma odpornost za navadno pršico (Milevoj, 1999). Pršica se v toplih in sušnih poletjih zagotovo namnoži tako, da se začno sušiti listi, cele rastline pa so že od daleč videti sivo rjave barve.

Uporaba fitofarmacevtskih sredstev (FFS) je pri gojenju krizantem precej intenzivna tako v pogledu količine, kakor tudi njihove večkratne uporabe. Gojitelji krizantem, ki v zavarovanih prostorih opravljajo različna negovalna dela, so trajno izpostavljeni fitofarmacevtskim sredstvom. Prav slednje nas je vspodbudilo, da izdelamo oziroma preiskusimo okolju prijazno tehnologijo gojenja lončnih krizantem ob uporabi najbolj primernega načina namakanja ter ugotovimo kako vpliva namakanje na razvoj pršice in ali obstaja pri sortah 'Veria Dark' in 'Cassablanca White' morfološka odpornost na pršico.

2 MATERIALI IN METODE

Poskus je potekal v rastlinjaku na Laboratorijskem polju Biotehniške fakultete, od druge polovice junija do konca oktobra, skupaj 133 dni v letu 2003 ter 128 dni v letu 2004. V poskus smo vključili mnogocvetni lončni krizantemi (*Chrysanthemum* L.) 'Veria Dark' (okrajšavi VD ali Vd) in 'Cassablanca White' (okrajšavi CS ali Cs), ki smo ju gojili v univerzalnem Klassman Tonsubstratu (K.T.) iz kakovostne bele šote (rušnata šota), premrznjene črne šote in iz glinenega granulata z visoko sorbcijsko sposobnostjo.

V letu 2003 smo preizkusili tehniko gojenja lončnih krizantem v odvisnosti od tehnike namakanja. Tovrstni podatki namreč pri nas niso javno dostopni, saj tehnološki list za krizanteme doslej ni objavljen. Tako smo se v letu 2003 najprej seznanili s krizantemami: npr. kako rastejo in ali obstojajo razlike v rasti in razvoju med sortama krizantem CS ('Cassablanca White') in VD ('Veria Dark') med namakanjema (K = kapljično namakanje, P = poplavno namakanje). Z opazovanjem in meritvami smo izvedli nadaljnja fenološka opazovanja po Vogelmannu (1969). V začetku smo lahko šteli le število listov na posamezno sadiko oz. glavni poganjek, kasneje smo s pomočjo metrskega traku merili velikost in širino grmičkov. Obe sorti sta tako pri poplavnem kot pri kapljičnem namakanju enakomerno napredovali in bili zelo izenačeni. V letu 2004 smo razvoj krizantem spremljali le informativno, da smo vedeli, v kateri razvojni fazi smo naselili pršice in v kateri razvojni fazi krizantem smo pršice opazovali in spremljali razvoj osebkov pod stereolupo (Remic, 2006).

Prvo leto smo v vsak gojitveni lonec premera 20 cm zatehtali 1000 g substrata. Vanje smo 17. junija 2003 posadili po tri sadike krizantem s koreninsko grudico. Dve mizi smo v letu 2003 namakali poplavno, drugi dve pa kapljično. V letu 2004 je tehnologija sajenja krizantem ostala podobna kakor v letu 2003. Krizanteme, 'Veria Dark' in 'Cassablanca White' smo sadili 24. junija 2004 v enake gojitvene lončke, kakor leta 2003, le da smo vsak lonec napolnili s po 1500 g Klassmanovega Tonsubstrata. Kapljični sistem je bil nameščen površinsko, in sicer štiri linije s kapljači kapacitete 2 l/h na razdalji 50 cm. Širina namakalne oziroma gojitvene mize je bila 1 m. Na vodomeru smo spremljali količino vode, ki je pritekala na namakalno površino in s tenziometri spremembo vodnega potenciala v substratu. Če se sila vezave vode v tleh povečuje (kar pokaže odčitek na tenziometru), potem moramo obroke kapljičnega namakanja povečati, če se sila vezave vode v tleh zmanjšuje, pa moramo obroke vode zmanjšati (Pintar, 2003). Količino porabljene vode ali čas namakanja smo sproti zapisovali. V letu 2004 smo namakali samo poplavno. Zalivali smo vsak drugi dan po 20 minut oziroma, ko je tenziometer pokazal, da je v lončkih že zelo malo vode, a še vedno nad poljsko kapaciteto. Od sredine oktobra (od 14. oktobra 2004), smo namakali samo še po 10

minut na dan, ker so bile tudi vremenske razmere takšne, da so krizanteme porabile manj vode, kot so jo porabile poleti. Z nameščeno merilno sondo v rastlinjaku smo v letu 2004 spremljali gibanje zračne vlage (%) in temperature (°C). Vzporedno smo spremljali zunanje vremenske razmere na prostem na meteorološki postaji Laboratorijsko polje Biotehniške fakultete v Ljubljani, dnevno količino padavin (mm) in temperaturo zraka (°C).

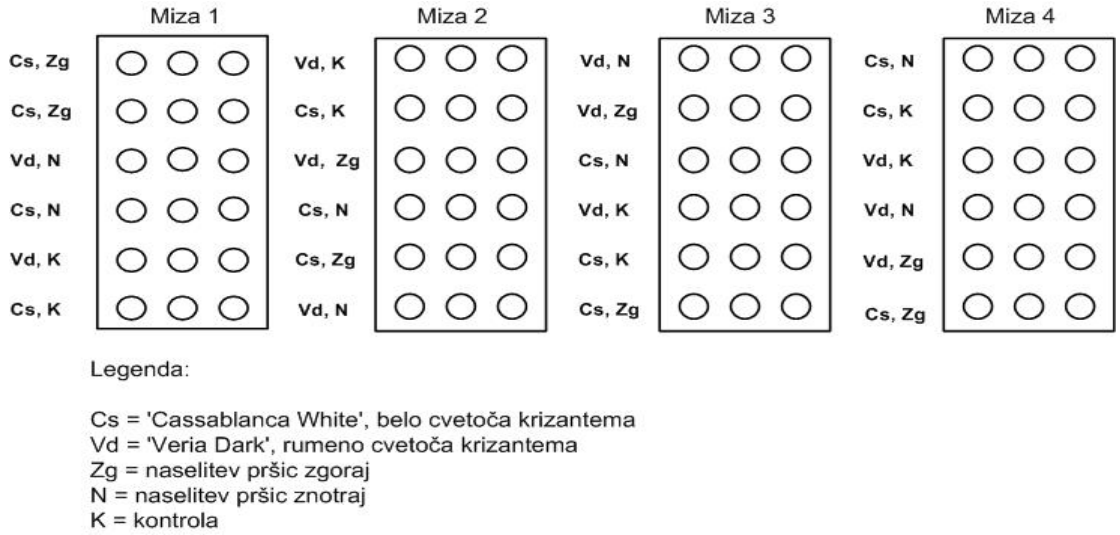
Zaradi prakse sajenja sadik s koreninsko grudico je bilo prvo dognojevanje potrebno šele čez približno 14 dni po sajenju. Koreninska grudica že vsebuje določeno zalogo hranil. Gnojila Kristalon, ki smo jih uporabili pri gojenju lončnih krizantem, imajo različno razmerje N, P, K in vsebujejo mikroelemente ter so primerna za posamezno rastno obdobje krizantem. Poimenovali smo jih po barvi Kristalon »zelen«, vsebuje elemente v razmerju 15 + 5 + 30 + 3 mikroelementi, Kristalon »moder«, vsebuje elemente v razmerju 19 + 6 + 20 + 3 mikroelementi, Kristalon »bel«, vsebuje elemente v razmerju 18 +18 + 18 ekstra + mikroelementi.

Druga tehnologija, pomembna pri gojenju lončnih krizantem, kot sta vršičkanje in škropljenje z zaviralcem rasti Alar 85 v 0,3% koncentraciji, je obe leti sledila priporočilom iz literature (Vogelmann, 1969; Tuenter, 2002; Pieters, 2002) in domače stroke (Gomzi, 2003). Varstvo pred škodljivci, če so se pojavili, smo opravili na podlagi opazovanj.

V letu 2003 smo škropili posamezne rastline proti listnim ušem (Aphididae) s pripravkom Chess 25 WP (pimetrozin) s karenco, zagotovljeno z načinom uporabe. Proti cvetličnemu resarju (*Frankliniella occidentalis*) smo škropili enkrat vse rastline s pripravkom Vertimec 1,8% EC (abamektin) s karenco, zagotovljeno z načinom uporabe. Proti beli rji (*Puccinia horiana*) smo dvakrat preventivno uporabili Stroby WG (kresoksim-metil 50%). V letu 2004 ni bilo težav z listnimi ušmi, temveč le s cvetličnim resarjem. V tem letu smo vse rastline dvakrat škropili proti resarju. Prvič smo uporabili pripravek Vertimec 1,8% EC, drugič pa pripravek Laser (spinosin A + spinosin D) s karenco zagotovljeno z načinom uporabe. Enkrat smo v letu 2004 škropili preventivno proti beli rji s pripravkom Stroby WG.

V letu 2003 smo na krizanteme tipalno naselili navadno pršico na polovico krizantem 'Veria Dark' in 'Cassablanca White', ki so bile stare od 4 do 6 tednov in od 30 do 50 cm visoke. Izhodno populacijo pršice smo zbrali na prostem na Laboratorijskem polju, ki smo jo namnožili na listih fižola 'Berggold' po metodi Kiełkiewicz-a in Vrie-ja (1990). Od 15 do 20 odraslih samic navadne pršice smo 4. avgusta leta 2003 prenesli v odprti plastičnih petrijevkah na rastline tako, da so se živalce lahko iz njih razlezle po listih. Po dveh tednih in kasneje vsak teden smo spremljali razvoj pršice na krizantemah tako, da smo z rastline naključno odtrgali po 4 liste, 2 lista iz osrednjega mladostnega dela rastline in 2 lista iz starejšega dela rastline in pregledali pršice pod stereolupo.

V letu 2004 smo statistično zasnovali poskus z obema sortama. Odločili smo se za en način namakanja (poplavno namakanje), na podlagi tipalnega (predposkusa) poskusa, ki nam je pokazal, da med namakanjema ni statistično značilnih razlik (ANOVA, $p > 0,05$). Tudi literatura poroča, da so bile rastline, gojene s poplavljanjem, veliko bolj izenačene (Debeljak, 2005; Osterc in Šiftar, 2002). Čisto populacijo navadne pršice smo pridobili v rastlinjaku na lepi hamedoreji (*Chamaedorea elegans* Mart.) iz okolice Ljubljane in jo kasneje namnožili na fižolu 'Berggold' za ciljno naselitev na krizanteme. Tako smo v letu 2004 pršice naselili na krizanteme konec avgusta (25. 08. 2004 ter 27. 08. 2004) t.j. dva tedna po drugem vršičkanju. Naselili smo od 15 do 20 pršic na vsak izbrani lonec (Slika 1), na dva načina, zgoraj (Zg) in znotraj (N) krošnje vsake sorte krizantem, zaradi spremljanja odziva sorte in načina naselitve na pršico. Postavili smo 6 obravnavanj: kontrola (K), dva načina naseljevanja (Zg, N) in dve sorti (Vd, Cs). Obravnavanja so bila slučajno razporejena znotraj mize (slučajni bloki).



Slika 1: *Razporeditev obravnavanj znotraj poplavnih miz (slučajnih blokov)*

Figure 1: *Random distribution of treatments within random blocks (flood tables)*

V letu 2004 smo razvoj pršic opazovali v treh sklopih opazovanj po 8 loncev vsake sorte krizantem, kar je skupno 16 loncev v enem opazovanju. V prvem opazovanju (od 4. do 10. 8.) smo iz prvega lonca pregledali 400 naključno izbranih listov po celi rastlini in 43 naključno izbranih vršičkov. V drugem opazovanju (od 24. do 30. 9.) smo iz drugega lonca potrgali enako število listov in vršičkov, v tretjem opazovanju (od 14. do 20. 10.) smo iz tretjega lonca pregledali 400 listov in 69 posameznih cvetov, da bi ugotovili, kako so se pršice naselile po višini rastline. Izid poskusa je število pršic v različnih razvojnih stadijih: skupno število J (jajčec), L_1 (ličink 1), $L_{2,3}$, F (samic) in M (samcev) na eno enoto (en lonec) v času od naselitve do cvetenja krizantem. Pršice smo šteli pod stereolupo Olympus.

Zanimalo nas je, ali obstajajo razlike v poraščenosti listov pri obeh sortah krizantem, in ali poraščenost listov vpliva na razvoj in ovipozicijo navadne pršice. Vrednost gostota nežlezastih dlačic je definirana kot število dlačic na površinsko enoto, kvadratni centimeter (cm^2) tako za stare kot za mlade liste obeh sort. Šteli smo po metodi, ki se uporablja za štetje listnih rež (McMahon in Kelly, 1995) pod stereolupo Olympus Europe SZH 10 (Research stereo). Šteli smo dlačice na zgornji in na spodnji strani listov. V poskus smo zajeli 12 slučajno izbranih krizantem posamezne sorte, kar je skupaj 24 loncev obeh sort. Z vsake rastline smo potrgali 5 starejših in 5 mladih listov. Starejši listi so definirani kot listi spodnje etaže krizanteme, mlajši pa kot listi zgornje etaže krizanteme, ki se zaključuje z vršički, in sicer prvi štirje popolnoma razviti listi pod vršičkom (Stavrinides in Skirvin, 2003). Na vsaki strani listne ploskve vsakega lista smo izvedli po tri meritve.

Statistična analiza

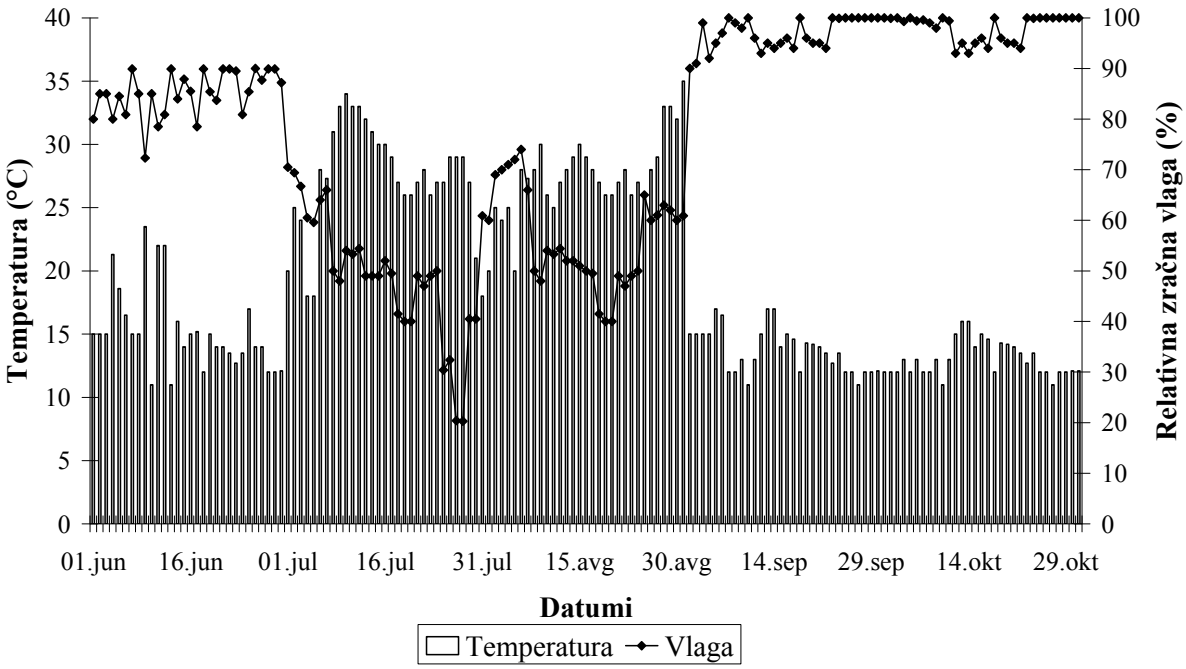
V letu 2003 smo izdelali in preverili metodo naselitve navadne pršice na krizanteme. V letu 2004 pa smo postavili dvofaktorski poskus v bločni poskusni zasnovi. Z analizo variance smo ugotovljali vpliv sorte na naselitev in način naselitve navadne pršice na krizanteme. Podatke za število jajčec, ličink prve, druge in tretje levitvene faze ter samic in samcev smo transformirali s korensko transformacijo, da so bile predpostavke ANOVA izpolnjene.

Iz meritev, ki smo jih dobili s štetjem trihomov (dlačic) na zgornji in spodnji strani starejših in mlajših listov obeh sort krizantem, smo izračunali povprečja in standardno napako. Na podlagi analize variance pri 0,05 stopnji značilnosti smo želeli ugotoviti, ali obstajajo razlike med sortama krizantem v poraščenosti s trihomi.

3 REZULTATI

Poskus v letu 2003 je usmerjen na preizkušanje tehnologije gojenja krizantem in tehnologijo namakanja, ki pomembno vpliva na navadno pršico in na izdelavo metode naselitve navadne pršice. Tehnologija gojenja krizantem je bila ustrezna, kar se je odrazilo v optimalnem cvetenju obeh sort. Način namakanja v letu 2003 ni vplival na začetek cvetenja krizantem. Sedemindvajsetega oktobra je začela cveteti sorta 'Cassablanca White' in enaindvajsetega oktobra sorta 'Veria Dark'. Opisan način naselitve navadne pršice na krizanteme v letu 2003 je bil ustrezen, kar je podrobno opisala Remičeva (Remic, 2006). Leto 2003, ko so se povprečne mesečne temperature v času gojenja krizantem (od junija do začetka septembra) gibale od 22,0°C do 23,5°C in je povprečna dnevna količina padavin v mesecu znašala od 2 mm do 3 mm, je bilo izrazito ugodno za navadno pršico, ki se je množično pojavljala na gojenih rastlinah (Remic, 2006).

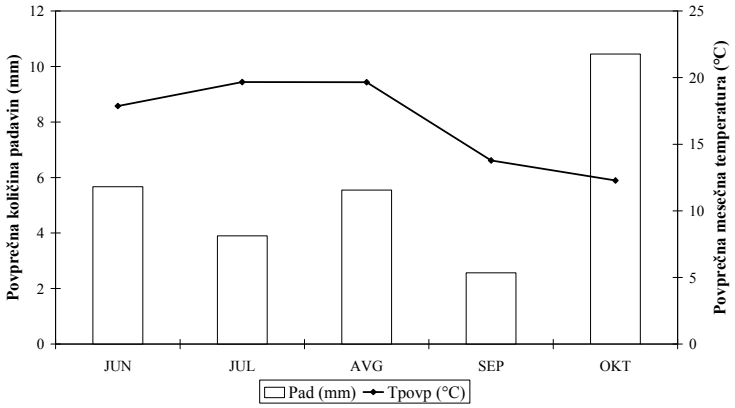
Rezultati iz leta 2004 so prikazani na slikah 2 do 8. Slika 2 prikazuje povprečno dnevno gibanje temperature in relativne zračne vlage v rastlinjaku v letu 2004, od 1. julija do 31. oktobra. Nizka temperatura in visoka relativna zračna vlaga v rastlinjaku sta posledica vremenskih razmer v letu 2004, ki sta zadrževali razmnoževanje navadne pršice na krizantemah.



Slika 2: *Povprečna dnevna temperatura zraka (°C) in povprečna dnevna relativna zračna vlaga (%) v rastlinjaku po mesecih, v času gojenja krizantem in navadne pršice na njih v letu 2004*

Figure 2: *The average day air temperature (°C) and the average day air humidity (%) in the greenhouse according to individual months during chrysanthemums and twospotted spider mite farming, in 2004*

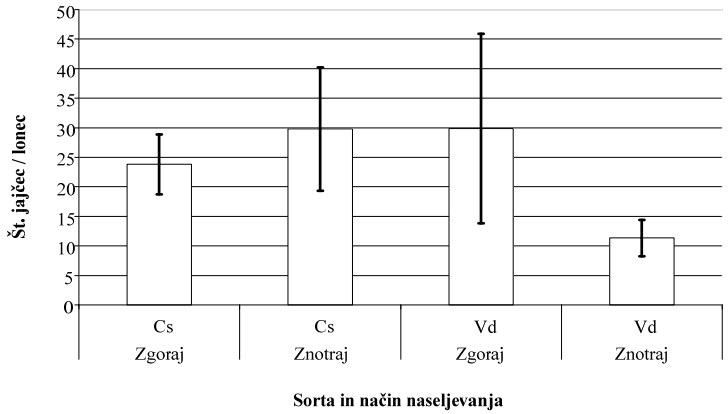
Slika 3 prikazuje povprečno količino padavin (mm) in povprečno temperaturo zraka po mesecih od junija do oktobra 2004, merjeno na Laboratorijskem polju Biotehniške fakultete.



Slika 3: *Mesečna količina padavin (mm) in povprečna temperatura zraka (°C) v letu 2004 po mesecih na Laboratorijskem polju Biotehniške fakultete*

Figure 3: *The monthly rainfall (mm) and the average air temperature (°C) in 2004, according to the data of the experimental field of Biotechnical Faculty*

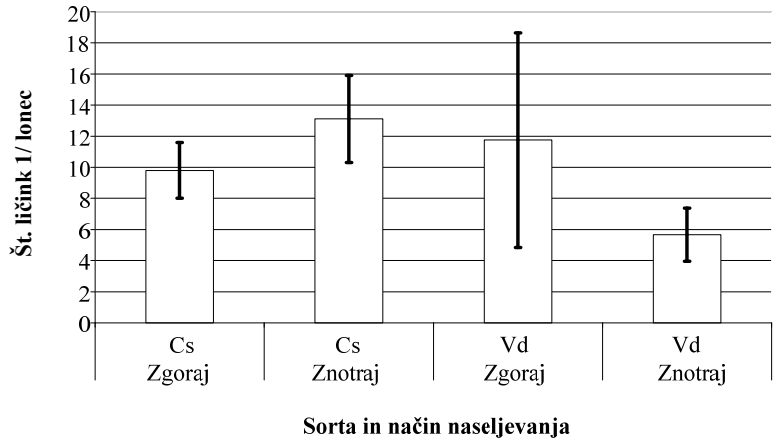
Na slikah od 4 do 7 so prikazani rezultati treh štetij osebkov navadne pršice v letu 2004. Slike prikazujejo tudi standardno napako povprečja meritev. ANOVA na transformiranih podatkih za število jajčec ni pokazala statistično značilnih interakcij med sortama in načinom naseljevanja ($p > 0,05$). Enako lahko trdimo za število ostalih razvojnih stadijev navadne pršice: ličink prve levitvene faze (L1), ličink druge in tretje levitvene faze (L2,3) ter samic in samcev. Na sorti 'Cassablanca White' smo znotraj grmička našteli po 30 jajčec, zgoraj pa manj kot 25; pri sorti 'Veria Dark' 30 jajčec zgoraj, najmanj znotraj (Slika 4).



Slika 4: *Povprečno število jajčec navadne pršice (Tetranychus urticae Koch) po obravnavanjih (način naseljevanja zgoraj in znotraj grmička krizanteme, Cs = 'Cassablanca White', Vd = 'Veria Dark' s standardno napako povprečja meritev*

Figure 4: *The average number of twospotted spider mite (Tetranychus urticae Koch) eggs according to treatments (colonization on and inside the chrysanthemum shrubs; Cs = 'Cassablanca White', Vd = 'Veria Dark') with standard measurement error of data averages*

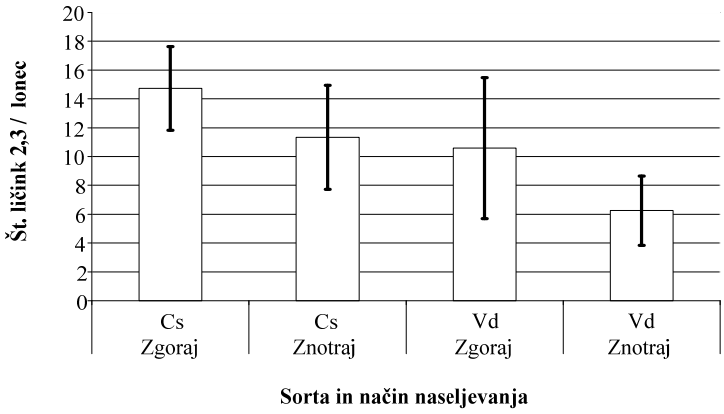
V enakem zaporedju je bilo število izleglih ličink L1 (Slika 5), ki je pri sorti 'Cassablanca White' znotraj grmička 13, sledi 'Veria Dark' zgoraj grmička 10 in 'Cassablanca White' zgoraj manj kot 12 ter 'Veria Dark' znotraj manj kot 6.



Slika 5: *Povprečno število ličink (L1) navadne pršice (Tetranychus urticae Koch) po obravnavanjih (način naseljevanja zgoraj in znotraj grmička krizanteme, Cs = 'Cassablanca White', Vd = 'Veria Dark') s standardno napako povprečja meritev*

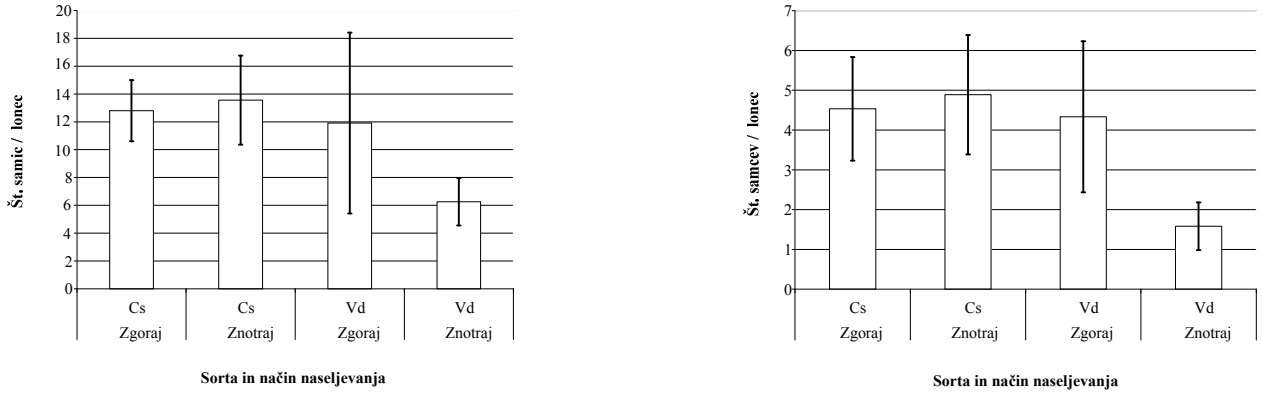
Figure 5: *The average number of twospotted spider mite (Tetranychus urticae Koch) first-stage larvae according to treatments (colonization on and inside the chrysanthemums shrubs; Cs = 'Cassablanca White', Vd = 'Veria Dark') with standard measurement error of data averages*

Ličinke druge in tretje levitvene faze so se bolj množile na sorti 'Cassablanca White' kot na sorti 'Veria Dark', vendar pri obeh v zgornjem delu grmičkov (Slika 6).



Slika 6: *Prikaz povprečnega števila ličink (L2, L3) navadne pršice (Tetranychus urticae Koch) po obravnavanjih (način naseljevanja zgoraj in znotraj grmička krizanteme, Cs = 'Cassablanca White', Vd = 'Veria Dark') s standardno napako povprečja meritev*

Figure 6: *The average number of twospotted spider mite (Tetranychus urticae Koch) second- and third-stage larvae according to treatments (colonization on and inside the chrysanthemums shrubs; Cs = 'Cassablanca White', Vd = 'Veria Dark') with standard measurement error of data averages*

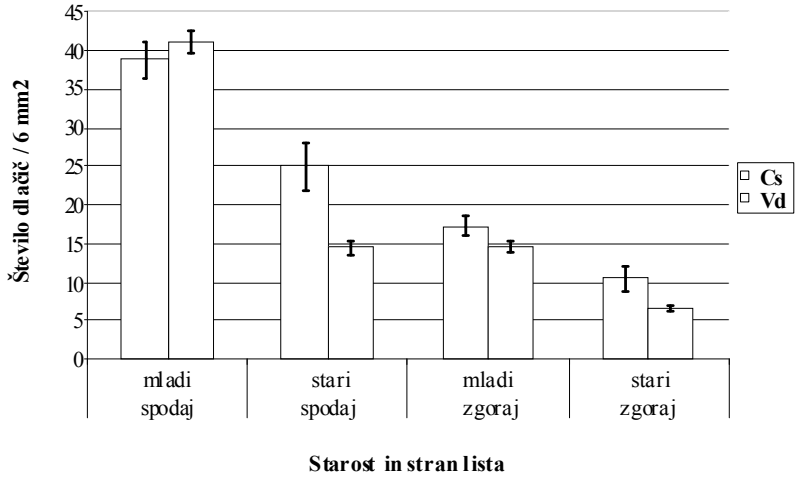


Slika 7: *Povprečno število samic (levo) in samcev (desno) navadne pršice (Tetranychus urticae Koch) po obravnavanjih (način naseljevanja zgoraj in znotraj grmička krizanteme, Cs = 'Cassablanca White', Vd = 'Veria Dark') s standardno napako povprečja meritev*

Figure 7: *The average number of the twospotted spider mite (Tetranychus urticae Koch) females (left) and males (right) according to treatments (colonization on and inside the chrysanthemums shrubs; CS = 'Cassablanca White', Vd = 'Veria Dark') with standard measurement error of data averages*

Slika 8 prikazuje povprečno število dlačic s standardno napako povprečnih meritev. Na gostoto poraščenosti listov vplivajo sorta, stran lista in starost lista ($p < 0,05$). Tako se je pri analizi variance pokazala zelo značilna trojna interakcija ($p = 0,00$). Največji vpliv na poraščenost ima stran lista (največje F-razmerje = 214,02), potem sledi starost lista. Najmanj je bila poraščenost listov odvisna od sorte. Zgornja stran lista je manj poraščena kot spodnja stran, starejši listi so manj dlakavi kot mlajši listi.

Navadna pršica je na krizantemah odlagala jajčeca razpršeno med žilami in ne ob žilah. Res pa je, da ko smo pregledali 400 listov vsake krizanteme v enem opazovanju, smo največ samic in jajčec našli na spodnjih, najstarejših listih in na spodnji strani listne ploskve. Na zgornji strani nismo zasledili odloženih jajčec.



Slika 8: *Povprečno število nežleznih dlačic (trihomov) za posamezno sorto krizantem (Cs = 'Cassablanca White', Vd = 'Veria Dark') pri mladih in starih listih posamezne sorte*

Figure 8: *The average number of non-glandular trichomes in new and old leaves, according to individual chrysanthemums varieties (Cs = 'Cassablanca White', Vd = 'Veria Dark')*

Poraščenost krizantem s trihomi vpliva na naselitev navadne pršice. Samice navadne pršice najprej naseljujejo spodnje liste krizantem, kjer tudi najprej odlagajo jajčeca, nato se počasi selijo navzgor po rastlini (srednji del rastline – srednja poraščenost z dlačicami), medtem ko jih v zgornjem delu krizantem (visoka poraščenost) nismo zasledili. Poleg tega samice navadne pršice ne morejo odlagati jajčec ob listne žile, kakor na liste fižola 'Berggold', ker so listne žile pri krizantemah veliko bolj poraščene od ostalega dela lista. Tako samice navadne pršice odlagajo na krizanteme jajčeca razpršeno po spodnji strani listne ploskve, za primerjavo na fižolu pa ob listnih žilah.

V letu 2004 je sorta 'Cassablanca White' zacvetela 25. oktobra, sorta 'Veria Dark' pa 27. oktobra. Gojenje krizantem 'Veria Dark' in 'Cassablanca White' je bilo tako obe leti v poskusu uspešno. Rastline ene in druge sorte so bile izenačenega videza, bujne in so v obeh letih enakomerno zacvetele v optimalnem času. Poškodb zaradi navadne pršice ni bilo.

4 RAZPRAVA

Glede na to, da se je pri nas gojenje krizantem zelo uveljavilo, v zadnjih desetih letih tudi gojenje mnogocvetnih krizantem ('multiflora'), tehnike gojenja pa so k nam vpeljane iz drugih evropskih držav, zlasti iz Nizozemske, nas je pritegnilo vprašanje o zdravstvenem varstvu krizantem v naših razmerah, ob uporabi pri nas obstoječe agrotehnike in v povezavi s škodljivimi organizmi, ki so pri nas razširjeni. Za okrasne rastline, gojene v zavarovanih prostorih, velja pravilo, da se morejo s pravilnimi in optimalnimi tehnikami gojenja dosegati nadstandardne estetske zahteve, ki pa pogosto prispevajo k slabi odpornosti rastlin za bolezni in škodljivce (Tanigoshi in sod., 2001). Med organizmi, ki pridelovalcem krizantem v rastlinjakih povzročajo občasne težave, je navadna pršica (*Tetranychus urticae* Koch), ki na krizantemah še ni bila preučevana pri nas; tudi drugje je v tem pogledu malo raziskana. Zaradi zgornje ugotovitve smo izbrali dve sorti 'Veria Dark' in 'Cassablanca White', pri katerih je bilo pri gojiteljih lončnih krizantem opaženo, da se na njih občasno pojavlja navadna pršica (Gomzi, 2003). Iz dostopnih virov nismo mogli ugotoviti, ali sta navedeni sorti dejansko občutljivi za navadno pršico ali sta tolerantni.

Pomemben gojitveni dejavnik je oskrba krizantem z vodo. Preiskušali smo dva načina namakanja krizantem (kapljično in poplavno) in vključevali druge zahtevane postopke gojenja: vršičkanje, dognojevanje, varstvo.

Rastline so bile ves čas v dobri kondiciji in brez bolezenskih znamenj. Sorti krizantem sta začeli cveteti pri obeh načinih namakanja istočasno in ni bilo med njima razlik v začetku cvetenja zaradi različnega načina namakanja. Dostopna literatura poroča o poskusih iz Nemčije, da se je gojenje lončnih krizantem z namakalnim sistemom (»ebb in flow«) preko folije izkazalo za boljše od kapljičnega namakanja. Krizanteme, gojene s poplavnim namakalnim sistemom, so tudi prej cvetele (Altmann, 2000, cit. po Osterc in Šiftar, 2002). Najverjetneje moramo zgodnejši termin cvetenja krizantem, gojenih z namakalnim sistemom, v poskusih iz Nemčije pripisati bolj enakomernemu dognojevanju rastlin z dušikom preko poplavnega namakanja. V našem poskusu smo dognojevanje izvajali ročno, in sicer s tremi vrstami gnojil z različno vsebnostjo dušika.

Iz dostopne literature je razvidno, da so rastline, gojene s poplavljanjem, bolj izenačene (Debeljak, 2005; Osterc in Šiftar, 2002). Na podlagi literature in tipalnega poskusa v letu 2003, smo se v letu 2004 odločili za poplavno namakanje. Poplavni sistem namakanja se je v letu 2004 izkazal za slabšega, saj je na krizantemah prihajalo do poškodb. Najverjetneje je do tega prišlo zaradi veliko večje količine padavin in nižjih temperatur v poletnih mesecih, kar se je odrazilo tudi v povišani relativni vlagi v rastlinjaku.

Navadno pršico smo naselili na krizanteme v predposkusu v letu 2003 zaradi izdelave metodike naselitve, ki je bila uspešna. V glavnem poskusu pa smo jo naselili 25. avgusta in 27. avgusta 2004, pri povprečni dnevni temperaturi 25°C in 60 do 65% relativni zračni vlagi, na zgornje, mlajše liste krizantem in na starejše liste v sredini grmička (krošnje), da bi ugotovili, kateri položaj listov pršicam bolj ustreza. Za naselitev smo uporabili od 15 do 20 odraslih samic na rastlino na fižolovih listih v petrijevkah, ki smo jih odprte polagali na vrh oziroma v sredino krošnje krizanteme. Pršice so se preselile na krizanteme, odložile jajčeca in se počasi namnoževale prek razvojnih faz L1, L2, L3 do imaga. Živalice so na krizantemah preživele, vendar niso dosegale gradacije, ki bi se odrazila na preučevanih krizantemah v obliki poškodb.To je bil tudi naš cilj z optimalno tehnologijo gojenja krizantem vzgojiti čimbolj zdrave rastline. Na podlagi uporabljene tehnike gojenja krizantem, ki smo jo vpeljali v poskus, in na podlagi rednega vizuelnega zdravstvenega pregledovanja rastlin ter preventivnega varstva, predvsem rastlinske higiene, smo omejili rabo fitofarmacevtskih sredstev na tri škropljenja (eno preventivno proti boleznim in dve kurativni proti škodljivcem), ki je sicer pri gojenju krizantem v praksi zelo izdatna.

Naslednji dejavnik, ki smo ga preučevali, je bil vpliv nežleznih dlačic ali poraščenost krizantem na naselitev navadne pršice. Najpomemnejši vlogi dlačic sta preprečevanje izsušitve in toplotna izolacija. Hkrati pa imajo dlačice nalogo varovanja rastlin. Trihomi nudijo naravno odpornost rastlinam, da se lahko delno ali popolnoma zavarujejo pred napadi zanje dovzetnih in škodljivih živali. Na rastlinah z gostejšimi, daljšimi ali bolj pokončnimi listnimi dlačicami (trihomi) so poškodbe največkrat manj izrazite. Te rastline so naravno odpornejše, tip takšne obrambe pa se imenuje fizikalna odpornost. Pogosto so tudi okrasne rastline porasle z dlačicami, še posebej krizanteme. Ravno pri njih delujejo dlačice negativno na škodljive žuželke. Tako so krizanteme razvile strategijo naravne obrambe pred škodljivci (Stavrinides in Skirvin, 2003).

V času treh pregledovanj krizantem smo opazili, da ne glede na način naseljevanja (zgoraj ali znotraj grmička) pršice najprej naselijo spodnje, najstarejše liste in šele potem prehajajo na višje ležeče liste. V vršičkih ali cvetovih pršic nismo zasledili. Samice navadne pršice so hitro prešle v diapavzalne oblike, kar pomeni, da kljub temu da so bile razmere za razvoj zadostne, je obstajal nek dejavnik, ki je imel omejitveni značaj.

5 SKLEPI

Na podlagi rezultatov dveletne raziskave podajamo naslednje sklepe:

1. Gojenje krizantem 'Veria Dark' in 'Cassablanca White' na integriran način, ob uporabljeni tehnologiji, je bilo uspešno. Rastline prve in druge sorte so bile izenačenega videza, bujne in so enakomerno zacvetele v optimalnem času t.j. zadnji teden v oktobru.
2. Temperatura in vlaga vplivata na razmnoževanje in na naselitev navadne pršice na sorti krizantem 'Veria Dark' in 'Cassablanca White'. Zunanje vremenske razmere na prostem so se posredno odrazile tudi v rastlinjaku. Leto 2003, ko so se povprečne mesečne temperature v času gojenja krizantem (od junija do začetka septembra) gibale od 22,0°C do 23,5°C in je povprečna dnevna količina padavin v mesecu znašala od 2 mm do 3 mm, je bilo izrazito ugodno za navadno pršico, ki se je množično pojavljala na gojenih rastlinah. V letu 2004 se je povprečna mesečna temperatura od junija do začetka septembra gibala pod 20°C. V

istem obdobju se je povečala povprečna dnevna mesečna količina padavin na 4 mm do 6 mm. Na podlagi tega lahko sklepamo, da zaradi nižjih povprečnih mesečnih temperatur in večje količine padavin v mesecu avgustu in s tem tudi višje relativne zračne vlažnosti, razmere za navadno pršico niso bile ugodne.

3. Pri sortah krizantem 'Cassablanca White' in 'Veria Dark', gojenih v rastlinjaku, na gojitvenih mizah so bile manjše razlike v številu osebkov navadne pršice (*Tetranychus urticae* Koch) pri dveh načinih naseljevanja (zgoraj na mlajše liste grmička krizantem in znotraj grmička – krošnje – na starejše liste krizantem), ki pa niso bile statistično značilne.
4. Poraščenost krizantem s trihomi vpliva na naselitev navadne pršice. Samice navadne pršice najprej naseljujejo spodnje liste krizantem, kjer tudi najprej odlagajo jajčeca, nato se počasi selijo navzgor po rastlini (srednji del rastline – srednja poraščenost z dlačicami), medtem ko jih v zgornjem delu krizantem (visoka poraščenost) skoraj nismo zasledili. Samice navadne pršice odlagajo jajčeca na krizanteme razpršeno po spodnji strani listne ploskve, ne pa ob s trihomi poraščenih listnih žilah.
5. Zunanja temperatura in vlaga vplivata na naselitev in razmnoževanje navadne pršice (*Tetranychus urticae* Koch) na sorti krizantem 'Veria Dark' in 'Cassablanca White', kar se odraža posredno v rastlinjaku.
6. Uporaba fitofarmacevtskih (FFS) sredstev pri gojenju krizantem je bila obe leti minimalna. Rastline niso bile izpostavljene stresu zaradi FFS. Uporabljena tehnologija gojenja krizantem v rastlinjaku je ugodna tudi za osebje, ki neguje krizanteme, saj pri minimalni rabi FFS ni izpostavljeno njihovim stranskim vplivom. Opravil v rastlinjaku ni treba prekinjati ali prelagati, ker ni ovir zaradi delovnih karenc fitofarmacevtskih sredstev.

6 VIRI

Debeljak, M. 2005. Namakanje v rastlinjakih.V: Seminar. Namakanje v rastlinjakih, Ljubljana, Biotehniška fakulteta, Oddelek za agronomijo: 19 str. (neobjavljeno)

Gomzi, M. 2003. »Tehnologija gojenja lončnih krizantem«. Podbrezje, Vrtnarija Gomzi (osebni vir, junij 2003).

Janežič, F. 1975. Pršice prelke (Tetranychidae) v Sloveniji. V: Zbornik Biotehniške fakultete Univerze v Ljubljani. Ljubljana, Biotehniška fakulteta, Oddelek za agronomijo. (Zbornik Biotehniške fakultete Univerze v Ljubljani. Kmetijstvo (Agronomija), Suplement 25, 1: 29-35.

Kiełkiewicz, M., Van de Vrie M. 1990. Within-leaf differences in nutritive value and defence mechanism in chrysanthemum to the two-spotted spider mite (*Tetranychus urticae*). Experimental & Applied Acarology, 10: 33-43.

Lamparter, B. 1992. Nützlingseinsatz im Gemüsebau unter Glas. Braunschweig, Thalacker: 70 str.

Maceljski, M., Cvjetković, B., Igrc Barčić, J., Ostojić, Z., Barčić, J., Pagliarini, N., Oštrec, Lj., Čizmić, I. 1997. Zaštita povrća od štetočinja. Zagreb, Znanje d.d.: 435 str.

McMahon, M.J., Kelly, J.W. 1995. Anatomy and Developed pigments of chrysanthemum leaves under spectrally selective filters. Scientia Horticulturae, 64: 203-209.

Milevoj, L. 1999. Navadna pršica (fižolova, hmeljeva) *Tetranychus urticae* Koch, Acari, Tetranychidae. http://www.fito-info.si/index=OrgCirs\OpisSkod/vsi/tet-urt.htm (12. avgust 2009).

Milevoj, L. 2003. Vplivi namakanja na bolezni in škodljivce vrtnin. Ljubljana, MKGP: 35 str.

Osterc, G., Šiftar, A. 2002. Krizanteme: so novosti sploh še možne? Zb. Bioteh. Fak. Univ. Ljub. Kmet. 79, 1: 301-307.

Pagliarini, N. 1997. Sve o krizantemi. Zagreb, Hrvatsko agronomsko društvo: 184 str.

Parlevliet, G., Learmonth, S., Hardie, D., Botha, J. 2002. Understanding the Twospotted spider mite (*Tetranychus urticae*) on Cutflowers in Glasshouse. http://agspsrv34.agric.wa.gov.au/programs/hort/floriculture/twospot.htm (5. marec 2004).

Pieters, D. 2002. Gediflora 2002, Selection de chrysanthèmes. Oostnieuwkerke (België), Floramedia: 35 str.

Pintar, M. 2003. Osnove namakanja: s poudarkom na vrtninah in sadnih vrstah v severovzhodni Sloveniji. Ljubljana, MKGP: 49 str.

Remic, M. 2006. Dejavniki, ki vplivajo na naselitev navadne pršice (*Tetranychus urticae* Koch) na krizanteme *Chrysanthemum* 'Veria Dark' in 'Cassablanca White'. V: Magistrsko delo. Dejavniki, ki vplivajo na naselitev navadne pršice (*Tetranychus urticae* Koch) na krizanteme

Chrysanthemum 'Veria Dark' in 'Cassablanca White'. Ljubljana: 106 str. (neobjavljeno).

Sket, B., Gogala, M., Kuštor, V. 2003. Živalstvo Slovenije. Ljubljana, Tehniška založba Slovenije: 664 str.

Stavrinides, M. C., Skirvin, D. J. 2003. The effect of chrysanthemum leaf trichome density and Prey spatial distribution on predation of *Tetranychus urticae* (Acari: Tetranychidae) by *Phytoseiulus persimilis* (Acari: Phytoseiidae). Bulletin of Entomological Research, 93, 4: 343-350.

Tanigoshi, L. K., Martin, N. A., Osborne, L. S., Peña, J. E. 2001.Biological Control of Spider Mites on Ornamental Crops. Ball Publishing, Batavia, 9: 185-199.

Tuenter, A. 2002. Chrysanthemen 2002. Isselburg (Deutschland), Brandkamp GmbH: 38 str.

Vogelmann, A. 1969. Chrysanthemen. Stuttgart, Verlag Eugen Ulmer: 315 str.

Vrabl, S. 1992. Škodljivci poljščin. Ljubljana, Kmečki glas: 144 str.

Zhang, Z. 2003. Mites of Greenhouses. London, CABI Publishing: 244 str.

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Agris category code: F01

Vegetativna rast in pridelek semideterminantnega paradižnika (*Lycopersicon esculentum* Mill.) v odvisnosti od načina zastiranja tal

Dean BAN[1], Blanka SINČIĆ PULIĆ[2], Milan OPLANIČ[3], Josip BOROŠIĆ[4], Dragan ŽNIDARČIČ [5]

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IZVLEČEK

Cilj raziskave je bil ugotoviti, kako različni načini zastiranja tal vplivajo na vegetativno rast in pridelek semideterminantnega paradižnika na sredozemskem območju Hrvaške. Poljski poskus, ki je bil v dveh vegetacijskih sezonah zasnovan po metodi naključnih blokov v treh ponovitvah, je bil postavljen na družinski kmetiji v Pulju (44° 51' N, 13° 51' E, 12 m n. v.). V obravnavanje so bila vključena gola tla, tla prekrita s črno polietilensko (PE) folijo, in dve rastlinski zastirki (kuštrava grašica – *Vicia villosa* in inkarnatka – *Trifolium incarnatum*). Tla, prekrita s črno PE folijo, so v primerjavi z golimi tlemi skrajšala, tla, prekrita z rastlinskimi zastirkami, pa podaljšala število dni, potrebnih za oblikovanje zalistnikov in začetek cvetenja paradižnika. V prvih 15 oz. 30 dneh so rastline paradižnika hitreje rasle na tleh, prekritih s črno PE folijo, kot na tleh z rastlinskimi zastirkami. Prav tako je bil v primerjavi z rastlinskimi zastirkami večji pridelek zgodnjih plodov na tleh, prekritih s črno PE folijo. Način zastiranja pa ni vplival na težo plodov.

Ključne besede: rastlinske zastirke, inkarnatka, *Trifolium incarnatum*, kuštrava grašica, *Vicia villosa*, PE črna folija, paradižnik, *Lycopersicon esculentum*

ABSTRACT

VEGETATIVE GROWTH AND YIELD OF SEMIDETERMINATE TOMATO (*Lycopersicon esculentum* Mill.) **IN DEPENDENCE ON THE METHOD OF MULCHING SOIL**

The aim of the research was to find out how different ways of covering soil affect the vegetative growth and yield of semideterminate tomato in the Mediterranean area of Croatia. The field experiment which was set up as a randomized block design in three replications in the two successive vegetation seasons was carried out on family farm in the town Pula (44°52'N, 13°54'E, 10 m altitude). The experiment looked at the growth of tomatoes in bare soil, soil covered with black polyethylene (PE) film, and two cover crop mulches (hairy vetch – *Vicia villosa* and crimson clover – *Trifolium incarnatum*). The soil covered with black PE film compared to bare soil, shortened the number of days necessary for the formation of tomato suckers and the begininng of blooming of tomato plants. On the contrary, the soil covered with cover crop mulches prolonged the number of days necessary for formation of suckers and the begininng of blooming of plants. In the first 15 or 30 days of the growing period the tomato plants grew faster on the soil covered with black PE film than on the soil covered with cover crop mulches. There was higher yield of early fruits on soil covered with black PE film than on cover crop mulches. The method of covering, however, had no influence on the weight of the fruits.

Key words: cover crop mulch, crimson clover, *Trifolium incarnatum*, hairy vetch, *Vicia villosa*, PE black film, tomato, *Lycopersicon esculentum*

[1] Institute of Agriculture and Tourism, Carla Huguesa 8, CR-52 440 Poreč; e-mail: dean@iptpo.hr

[2] Region of Istria - Department for Agriculture, Forestry, Hunting, Fishery and Water Management, Šetalište Pazinske gimnazije 1, CR-52 000 Pazin

[3] Institute of Agriculture and Tourism, Carla Huguesa 8, CR-52 440 Poreč

[4] Vegetable Crop Department, Faculty of Agriculture, University of Zagreb, Svetošimunska c. 25, CR-10000 Zagreb

[5] Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, SI-1111 Ljubljana; e-mail: dragan.znidarcic@bf.uni-lj.si

1 UVOD

Zastiranje tal pri gojenju paradižnika (*Lycopersicon esculentum* Mill.) je v sodobni pridelavi te kulture neizogiben agrotehnični ukrep (Žnidarčič in sod., 2003). V ta namen se za gojenje plodov, namenjenih za svežo uporabo, najpogosteje uporablja polietilenska (PE) folija (Pan in sod., 1999). Uporabo PE folij je v vrtnarsko pridelavo vpeljal Emmert (1957) sredi prejšnjega stoletja. Poskusi s paradižnikom in tudi z drugimi vrtninami so pokazali, da različni tipi in barve PE folij vplivajo na rast rastlin, zvišujejo pridelek, omilijo napad škodljivcev, zatirajo plevele, zmanjšujejo evaporacijo in izpiranje hranil iz tal, vzdržujejo strukturo zemljišča, izboljšajo čistočo in kvaliteto plodov ter povečajo učinkovitost herbicidov (Lamont, 1993; Farias-Larios in Orozco-Santos, 1997; Walters, 2003; Ghosh in sod., 2006; Decoteau, 2007; Díaz-Pérez in sod., 2007; Hutton in Handley, 2007; Žanić in sod., 2009). Prav zato je uporaba PE folij, ki poleg visokih pridelkov in racionalizacije uporabe mineralnih gnojil in pesticidov omogočajo tudi varovanje oz. preprečujejo preobremenitev okolja, ena od glavnih smernic v ekološki pridelavi vrtnin (Phatak, 1992).

Vse večje povpraševanje po PE foliji v ZDA je pripeljalo do tega, da se je v preteklosti na kar 87 % površin kot zastirka uporabljala črna PE folija (Servise, 1992; Roe in sod., 1994). Zaradi tako velike uporabe PE folij je prišlo do težav pri reciklaži oz. pri uničevanju takšnega nerazgradljivega materiala, ki predstavlja velik problem za onesnaževanje okolja (Hemphill, 1993). Zato je vrsta raziskovalcev (Nicholson in Wien, 1983; Phatak, 1992; Creamer in Bennett, 1994; Hoyt in sod., 1994; Mwaja in Masiunas, 1994; Creamer in sod., 1996; Abdul-Baki, 1998a,b; Masiunas, 1998) kot možno zamenjavo za PE folijo predlagala uporabo rastlinskih zastirk. Pri tem se ostanki predhodnega posevka ne zaorjejo, ampak se zelena gmota pusti na površini tal (Ban in sod., 2008). Za tak način zastiranja tal Hoyt in sod. (1999) priporočajo setev prezimnih kultur zgodaj jeseni (predvsem leguminoz) in njihovo pomladno košnjo. Tako pokošeni ostanki ostanejo na njivi in se uporabljajo kot rastlinska zastirka za glavni posevek (Hoyt, 1999). Izbira rastline, namenjene zastiranju, mora biti prilagojena klimatskim in edafskim pogojem (Cherr in sod., 2006). Poleg tega naj bi rastline za zastiranje razvile čim več listne gmote, med vegetacijo naj bi fiksirale čim več dušika, odporne naj bi bile na nizke temperature in po košnji naj ne bi retrovegetirale (Abdul-Baki in sod., 1997). Tem zahtevam se najbolj približujejo kuštrava grašica (*Vicia villosa* L.), navadna grašica (*Vicia sativa* L.), inakarnatka (*Trifolium incarnatum* L.), podzemna detelja (*Trifolium subterraneun* L.), njivski grah (*Pisum sativum* subsp. *arvense* L. [Poir]) in njihove mešanice z ržjo (*Secale cerale* L.) (Shennan, 1992; Hoyt, 1999; Ban in sod., 2008).

Ker v literaturi nismo našli informacij o vplivu rastlinskih zastirk na rast in pridelek paradižnika, smo v naš poskus vključili semideterminantni paradižnik, ki je bil gojen na golih tleh, na tleh, prekritih s črno PE folijo, in na tleh, zastrtih s kuštravo grašico in inakarnatko.

2 MATERIAL IN METODE

Raziskava z gojenjem semideterminantnega paradižnik (*Lycopersicon esculentum* Mill., cv. 'Professional F1') na različnih vrstah zastirk je bila opravljen na družinski kmetiji v okolici Pulja (44° 51' N, 13° 51' V, 10 m n. v.) v dveh vegetacijskih sezonah. Na podlagi priporočil Teasdaleja in Abdul-Bakija (1995) ter Abdul-Bakija in sod. (1996) smo za rastlinsko zastirko uporabili kuštravo grašico (*Vicia villosa*, cv. 'Poppelsdorfer') in inakarnatko (*Trifolium incarnatum* L., cv. 'Inkara'), ki smo ju primerjali z 0,04 mm debelo črno PE folijo ter golimi tlemi.

Priprava poskusa je v obeh letih potekala enako. Poskusna zasnova je bila postavljena v obliki latinskega kvadrata v štirih ponovitvah. Velikost osnovnih parcelic je znašala 2,6 × 7 m oz. 18,2 m^2. Tla so bila preorana na globino 25–30 cm. Po osnovni obdelavi so bile parcelice, na katerih smo gojili rastlinsko zastirko, pognojene s 500 kg/ha NPK 7-20-30 (to količino hranil rastline v povprečju porabijo v vegetacijskem obdobju). Preostalih parcelic nismo gnojili z mineralnimi gnojili. Inkarnatko in grašico smo posejali konec avgusta, in sicer inkarnatko na medvrstno razdaljo 15 cm (55 kg/ha) ter grašico na medvrstno razdaljo 20 cm (130 kg/ha). Obe sta bili ročno pokošeni ob polnem cvetenju v začetku maja. Pokošena rastlinska gmota je bila enakomerno razporejena po parcelicah v debelini približno 10 cm. Na vseh parcelicah je bil postavljen tudi namakalni sistem. 8. maja (v obeh sezonah) smo ročno posadili 8 tednov stare sadike paradižnika na razdaljo 60 × 50 cm, tako da je bilo na vsaki parcelici posajenih 28 rastlin. Tedensko dognojevati s tekočim mineralnim gnojilom Fertina 7-5-9 smo začeli en mesec po presajanju, tako da smo med vegetacijo rastline pognojili s 112 kg N/ha, 80 kg P_2O_5/ha in 144 kg K_2O/ha.

Začetek tvorbe zalistnikov in začetek cvetenja smo ugotavljali, ko je bilo več kot 50 % rastlin v tej fenofazi. Pri tem smo upoštevali zalistnike, večje od dveh centimetrov, in prvi popolnoma razvit cvet v socvetju. Višino rastlin smo ugotavljali 15. in 30. dan po presajanju. Plodove smo začeli pobirati, ko je zelena barva kože začela prehajati v oranžno. Sortirali smo jih na tržne in netržne (poškodovani in plodovi, lažji od 4 dag), pobirali pa smo jih dvakrat na teden do propada rastlin. Prva štiri pobiranja smo vzeli kot osnovo za pridelek zgodnjih plodov, preostala pobiranja pa smo šteli med pozne plodove.

Rezultate, zbrane v raziskavi, smo uredili v programu EXCEL XP in jih analizirali s programskim paketom MSTAT-C (Nissen, 1983). Statistično značilne razlike smo preverjali z Duncanovim testom, pri katerem smo upoštevali 5-odstotno tveganje.

3 REZULTATI IN DISKUSIJA

Začetek pojavljanja zalistnikov je tesno povezan z začetkom cvetenja, zato smo ti dve značilnosti spremljali skupaj. Število dni, ki so pretekli od presajanja do pojava zalistnikov oz. do cvetenja, je prikazano v Preglednici 1.

V obeh vegetacijskih sezonah so rastline paradižnika, gojene na črni PE foliji, v primerjavi s preostalimi načini zastiranja začele prve oblikovati zalistnike. Tudi rastline na golih tleh so značilno hitreje oblikovale zalistnike v primerjavi z rastlinami, gojenimi na rastlinskih ostankih. Podoben trend smo v obeh letih zaznali tudi pri začetku cvetenja: rastline na črni PE foliji so zacvetele 2 oz. 3 dni prej od tistih na golih tleh. Najkasneje so pognale cvetove rastline, gojene na rastlinskih zastirkah, ki so za rastlinami na črni PE foliji zaostale za 5 oz. 6 dni. Do podobnih rezultatov sta v svojih raziskavah prišla tudi Teasdale in Abdul-Baki (1995), ki menita, da je hitrejši razvoj paradižnika, gojenega na črni PE foliji, povezan z razliko v temperaturi pod različnimi vrstami zastirk neposredno po presajanju. Ugotovila sta namreč, da je temperatura tal pod črno PE folijo na globini 5 oz. 15 cm za 5,7 oz. za 3,4 °C višja od temperature tal, ki so bila prekrita z ostanki kuštrave grašice.

***Preglednica 1**: Pojav zalistnikov, začetek cvetenja in višina rastlin*

***Table 1**: Forming axillary shoots (suckers), begin blooming and height of plants*

Način zastiranja	Število dni od presajanja do pojava zalistnikov	Število dni od presajanja do začetka cvetenja	Višina rastlin 15 dni po presajanju (cm)	Višina rastlin 30 dni po presajanju (cm)
		Prva vegetacijska sezona		
Kontrola	12 c	17 c	23,91 a	46,88 a
Črni PE film	9 d	12 d	26,39 a	44,85 a
Kuštrava grašica	19 b	24 b	19,73 b	35,63 b
Inkarnatka	21 a	27 a	18,99 b	31,95 c
		Druga vegetacijska sezona		
Kontrola	13 b	18 b	21,75 b	50,90 a
Črni PE film	11 c	15 c	23,85 a	53,95 a
Kuštrava grašica	16 a	20 a	23,55 a	51,68 a
Inkarnatka	16 a	21 a	23,50 a	51,36 a

* Povprečne vrednosti izmerjenih parametrov v stolpcu, ki so označene z isto črko, se med seboj statistično značilno ne razlikujejo (Duncan test, $P<0,05$).

Višina rastlin po prvih dveh tednih oz. po prvem mesecu rasti je prav tako pomemben kazalec vitalnosti rastlin. V prvi vegetacijski sezoni so bile rastline, gojene na črni PE foliji, po 15 in po 30 dneh po presajanju višje od rastlin, gojenih na rastlinskih zastirkah, te pa se niso razlikovale od rastlin, gojenih na golih tleh. V drugi sezoni pa so rastline na črni PE foliji in na rastlinskih ostankih po 15 dneh dosegle večjo višino v primerjavi z rastlinami na golih tleh, medtem ko po 30 dneh med obravnavanji nismo zaznali razlik. Ker so bile povprečne temperature v drugi sezoni (podatki niso prikazani) bliže gojitvenemu optimumu kot v prvi sezoni, zastiranje ni značilno vplivalo na višino rastlin.

V prvi sezoni so bile ugotovljene tudi značilne razlike med obravnavanji v tržnem pridelku zgodnjih plodov (Preglednica 2). Največji tržni pridelek v prvih štirih pobiranjih je dosegel pridelek paradižnika, gojenega na

črni PE foliji (1,59 kg/rastlino) in na golih tleh (1,30 kg/rastlino) – bil je skoraj trikrat večji kot pridelek paradižnika, gojenega na rastlinskih ostankih. V drugi sezoni smo prav tako dosegli najvišji pridelek na črni PE foliji, vendar so bile razlike zaradi ugodnejših temperatur manj izrazite. Do podobnih rezultatov so prišli Abdul-Baki in sod. (1993), Abdul-Baki in Teasdale (1993, 1997), Teasdale in Abdul-Baki (1995) ter Abdul-Baki in sod. (1996a) v večletnih poskusih. Večji pridelek na črni PE foliji je predvsem posledica hitrejšega segrevanja tal in boljšega sprejema hranil pod folijo, zaradi česar rastline v začetku hitreje rastejo in plodovi prej dozorijo kot na rastlinskih ostankih (Wien in sod., 1993).

***Preglednica 2**: Tržni pridelek in teža plodov paradižnika*

***Table 2**: Marketable yield and fruit weight of tomato*

Način zastiranja	Zgodnji plodovi		Pozni plodovi		Plodovi skupaj	
	Teža plodov		Teža plodov		Teža plodov	
	(kg/rast.)	(g/plod)	(kg/rast.)	(g/plod)	(kg/rast.)	(g/plod)
	Prva vegetacijska sezona					
Kontrola	1,30 a	137 a	2,62 a	110 a	3,92 ab	115 a
Črni PE film	1,59 a	152 a	2,49 a	120 a	4,08 a	130 a
Kuštrava grašica	0,56 b	145 a	2,65 a	112 a	3,21 b	122 a
Inkarnatka	0,40 b	150 a	2,79 a	127 a	3,19 b	130 a
	Druga vegetacijska sezona					
Kontrola	1,27 b	175 a	2,63 a	170 a	3,90 a	173 a
Črni PE film	1,95 a	175 a	2,45 a	150 b	4,40 a	157 a
Kuštrava grašica	0,99 b	190 a	3,21 a	165 ab	4,20 a	170 a
Inkarnatka	1,11 b	173 a	2,70 a	163 ab	3,81 a	165 a

* Povprečne vrednosti izmerjenih parametrov v stolpcu, ki so označene z isto črko, se med seboj statistično značilno ne razlikujejo (Duncan test, $P<0,05$).

Pozneje pobrani plodovi, ker jih je običajno tudi največ, pomembno vplivajo na skupni pridelek. Pridelek poznih plodov v naši raziskavi pa ni bil povezan z načinom zastiranja tal, razlik namreč nismo statistično dokazali. S tega vidika se naši rezultati ne ujemajo z ugotovitvami Abdul-Bakija in sod. (1993), Abdul-Bakija in Teasdaleja (1993), Teasdaleja in Abdul-Bakija (1995) ter Abdul-Bakija in sod. (1996b). Vsi ti avtorji navajajo, da je pozen pridelek plodov bistveno večji pri rastlinah, gojenih na rastlinskih ostankih kot pa na črni PE foliji ali na golih tleh. Prav tako se naši rezultati ne ujemajo z zaključki raziskav, ki so jih opravili Masiunas (1998), Hoyt (1999) in Rutledge (1999). Po trditvah teh avtorjev je bil pridelek plodov na črni PE foliji višji od pridelka plodov, ko je pridelek rasel na rastlinskih ostankih. Razlog za te nasprotujoče si ugotovitve gre najverjetneje iskati v različnih pedoklimatskih pogojih, v katerih so bili opravljani poskusi.

Skupni tržni pridelek sodi med najpomembnejše informacije za proizvajalca, in to tako z vidika gospodarnosti kot z vidika načrtovanja pridelave na določeni površini. V naši raziskavi smo le v prvi sezoni dobili značilno višji skupni pridelek plodov na črni PE foliji v primerjavi z obema rastlinskima zastirkama. Vrsta raziskovalcev (Abdul-Baki in sod., 1993; Abdul-Baki in Teasdale, 1993; Teasdale in Abdul-Baki, 1995; Abdul-Baki in sod., 1996a; Abdula-Baki in sod., 1996b) je s svojimi poskusi dokazala ravno nasprotno. Dobili so namreč večji skupni pridelek plodov na rastlinskih zastirkah kot na črni PE foliji. Do takšnih rezultatov pa so prišli, ker so rastline na rastlinskih zastirkah uspevale, v nasprotju z našo raziskavo v kateri je bilo vegetacijsko obdobje enako dolgo ne glede na način zastiranja tal, skoraj mesec dni dlje kot rastline na črni PE foliji. Do podobnih rezultatov pa so prišli Roe in sod. (1994) pri poskusu s papriko, v katerem so ugotovili, da plodovi dozorijo sočasno, ne glede na vrsto zastirke. V našem poskusu smo sicer dobili visok delež netržnih plodov oz. plodov s prenizko težo (rezultati niso prikazani) pri rastlinah, gojenih na črni PE foliji in na golih tleh. Rastline so pri teh dveh načinih prekrivanja tal namreč razvile veliko plodov, ki pa jih zaradi pomanjkanja listne mase v drugem delu vegetacije niso mogle »prehraniti«. Po drugi strani pa so rastline, gojene na rastlinskih ostankih, imele manj plodov, vendar večjo listno maso, a to v končni fazi ni pripomoglo k povečanju pridelka, ker so rastline hitro odmrle in so končale vegetacijo sočasno z rastlinami na črni PE foliji in na golih tleh.

Povprečna teža zgodnjih plodov se med različnimi obravnavanji v našem poskusu ni razlikovala. Treba je poudariti, da je bila v tem zgodnjem vegetacijskem

obdobju listna masa še nepoškodovana. Teasdale in Abdul-Baki (1995) sta ugotovila, da so rastline, gojene na črni PE foliji, imele večje plodove v primerjavi z rastlinami gojenimi na zastirki iz kuštrave grašice. Niti v naši raziskavi nismo prišli do takšnih ugotovitev. Nasprotno pa so v drugi sezoni rastline v kasnejšem obdobju pobiranja na črni PE foliji imele drobnejše plodove, kar je bilo posledica številnih zakrnelih plodov in propadanja listne mase na tej zastirki.

4 SKLEPI

Na podlagi dobljenih rezultatov lahko sklenemo, da je za vzgojo paradižnika na mediteranskem območju Hrvaške najbolj primerna črna PE folija, še posebno, če želimo imeti visok pridelek zgodnjih plodov. Rastlinske zastirke lahko uporabimo kot alternativo, predvsem v ekološkem načinu vrtnarjenja, zlasti še ker z njimi ne zmanjšamo skupnega pridelka plodov.

5 VIRI

Abdul-Baki, A.A. 1998a. Vegetable production system. Annual convention and trade show. Proceedings: Cultivating ideas. November 19-20, Pasco, Washington: 9–16.

Abdul-Baki, A.A. 1998b. Cover crop and vegetable production. Annual convention and trade show. Proceedings: Cultivating ideas. November 19-20, Pasco, Washington: 3–7.

Abdul-Baki, A.A., Stommel, J.R., Teasdale, J.R. 1993. Evaluation of processing tomato varieties in a sustainable agricultural system using hairy vetch mulch. Proceedings of the 24th Annual Meeting of the mid-atlantic vegetable workers conference. November 9-10, Delaware: 59–64.

Abdul-Baki, A.A., Stommel, J.R., Watada, A.E., Teasdale, J.R., Morse, R.D. 1996a. Hairy vetch mulch favorably impacts yield of processing tomatoes. HortScience, 31(3): 338–340.

Abdul-Baki, A.A., Teasdale, J.R. 1993. A no-tillage tomato production system using hairy vetch and subterraneane clover mulches. HortScience, 28(2): 106–108.

Abdul-Baki, A.A., Teasdale, J.R., Korcak, R.F. 1997. Nitrogen requirements of fresh-market tomatoes on hiry vetch and black polyethylene mulch. HortScience, 32(2): 217–221.

Abdul-Baki, A.A., Teasdale, J.R., Korcak, R., Chitwood, D.J., Huettel, R.N. 1996b. Fresh-market tomato production in a low-input alternative system using cover-crop mulch. HortScience, 31(1): 65–69.

Ban, D., Goreta, S., Borošić, J., Ilak Peršurić, A.S., Žnidarčič, D. 2008. Potential of hairy vetch and crimson clover as cover crops. Cereal Research Communications, 36, Suppl., part II: 919–922.

Cherr, C.M., Scholberg, J.M.S., McSorley, R. 2006. Green manure approaches to crop production: A synthesis. Agronomy Journal, 98: 302–319.

Creamer, N.G., Bennett, M.A. 1994. Cover crop management for processing tomato production. Abstracts of 91st annual meeting of the American Society for Horticultural Science. Oregon State University, Corvallis. HortScience 29(5): 428.

Creamer, N.G., Bennett, M.A., Stinner, B.R., Cardina, J., Regnier, E.E. 1996. Mechanisms of weed suppression in cover crop-based production systems. HortScience, 31(3): 410–413.

Decoteau, D.R. 2007. Leaf area distribution of tomato plants as influenced by polyethylene mulch surface color. HortTechnoloy, 17(3): 341–345.

Díaz-Pérez, J.C., Gitaitis, R., Mandal, B. 2007. Effect of plastic mulches on root zone temperature and on the manifestation of tomato spotted wilt symptoms and yield of tomato. Scientia Horticulturae, 114: 90–95.

Emmert, E. 1957. Black polyethylene for mulching vegetables. Proceedings, American Society of Horticultural Science, 69: 464–469.

FAOSTAT, 2009. http://www.fao.org

Farias-Larios, J., Orozco-Santos, M. 1997. Effect of polyethylene mulch colour on aphid populations, soil temperature, fruit quality, and yield of watermelon under tropical conditions. New Zeland Journal of Crop and Horticultural Science, 25: 369–374.

Ghosh, P.K., Dayal, D., Bandyopadhyay, K.K., Mohanty, M. 2006. Evaluation of straw and polythene mulch for enhancing productivity of irrigated summer groundnut. Field Crops Rresearch, 99: 76–86.

Ham, J.M., Kluitenberg, G.J., Lamont, W.J. 1993. Optical properties of plastic mulches affect the field temperature regime. Journal of the American Society for Horticultural Science, 118(2): 188–193.

Hemphill, D.D.Jr. 1993. Agricultural plastics as solid waste: what are the options for disposal? HortTehnology, 3(1): 70–73.

Hoyt, G.D., Monks, D.W., Monaco, T.J. 1994. Conservation tillage for vegetable production. HortTechnology,4(2): 129–135.

Hoyt, G.D. 1999. Tillage and cover residue affects on vegetable yields. HortTechnology, 9(3): 351–358.

Hutton, M.G., Handley, D.T. 2007. Effects of silver reflective mulch, white inter-row mulch, and plant density on yields of pepper in Maine. HortTechnology 17(2): 214–219.

Lamont, Jr.W.J. 1993. Plastic mulches for the production of vegetable crops. HortTehnology, 3(1): 35–39.

Lešić, R., Borošić, J., Butorac, I., Ćustić, M., Poljak, M., Romić, D. 2002. Rajčica. V: Povrćarstvo, Sveučilište u Zagrebu, 259–294.

Masiunas, J.B. 1998. Production of vegetables using cover crop and living mulches – a review. Journal of Vegetable Crop Production, 4(1): 11–31.

Mwaja, V.N., Masiunas, J.B. 1994. Winter cover crops for weed control in sustainable vegetable production. Abstracts of 91st Annual meeting of the American Society for Horticultural Science. HortScience, 29(5): 428.

Nicholson, A.G., Wien, H.C. 1983. Screening of turfgrass and clovers for use as living mulches in sweet corn and cabbage. Journal of American Society of Horticultural Science, 108: 1071–1076.

Nissen, O. 1983. MSTAT-C User`s manual. Version 1. Michigan State University.

Phatak, S.C. 1992. An integrated sustainable vegetable production system. HortScience, 27(7): 738741.

Roe, N.E., Stoffella, P.J., Bryan, H.H. 1994. Growth and yields of bell pepper and winter squash grown with organic and living mulches. Journal of American Society of Horticultural Science, 119(6): 1193–1199.

Rutledge, A.D. 1999. Experiences with conservation tillage vegetables in Tennessee. HortTechnology, 9(3): 366–372.

Shennan, C. 1992. Cover crops, nitrogen recycling and soil properties in semi-irrigated vegetable production system. HortScience, 27: 749–753.

Teasdale, J.R., Abdul-Baki, A.A. 1995. Soil temperature and tomato growth associated with black polyethylene and hairy vetch mulches. Journal of American Society of Horticultural Science, 120(5): 848–853.

Walters, S.A. 2003. Suppression of watermelon mosaic virus in summer squash with plastic mulches and rowcovers. HortTechnology, 13(2): 352–357.

Wien, H.C., Minotti, P.L., Grubinger, V.P. 1993. Polyethylene mulch stimulates early root growth and nutrient uptake of transplanted tomatoes. Journal of American Society of Horticultural Science, 118(2): 207–211.

Žanić, K., Ban, D., Škaljac, M., Dumičić, G., Goreta Ban, S., Žnidarčič, D. 2009. Aphid population in watermelon (*Citrullus lanatus* Thunb.) production Acta agriculturae Slovenica, 93(2): 198–192.

Žnidarčič, D., Trdan, S., Zlatič, E. 2003. Impact of various growing methods on tomato (*Lycopersicon esculentum* Mill.) yield and sensory quality. Research Reports of Biotechnical Faculty, University of Ljubljana, Agriculture, 81: 341–348..

CONTENT ANALYSIS OF THE PAPERS IN THE ACTA AGRICULTURAE SLOVENICA

VSEBINSKA OBDELAVA PRISPEVKOV V ACTA AGRICULTURAE SLOVENICA let. 93 št. 3

Tomaž BARTOL[a], Karmen STOPAR[b],

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a Ph. D., M. Sc.., B. Sc., Jamnikarjeva 101, SI-1000 Ljubljana, P. O. Box 95

b B.Sc., M.Sc., ibid.

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Ob 80-letnici dolgoletnega urednika Zbornika Biotehniške fakultete, akademika zaslužnega profesorja dddr. Jožeta Mačka

28. oktobra 2009 je dopolnil 80 let akademik, zaslužni profesor dddr. Jože Maček, dolgoletni glavni in odgovorni urednik ter sodelavec Zbornika Biotehniške fakultete (danes revija Acta Agriculturae Slovenica).

Akademik Jože Maček, doktor agronomskih, zgodovinskih in ekonomskih znanosti, zaslužni profesor ljubljanske univerze, upokojeni redni profesor za fitopatologijo, gozdno fitopatologijo in fitofarmakologijo, dopisni član Hrvaške akademije znanosti in umetnosti, član Evropske akademije znanosti in umetnosti v Salzburgu, dobitnik Zoisove nagrade za življensko delo na področju fitomedicine, častni član Društva za varstvo rastlin Slovenije in dobitnik številnih drugih priznanj, vseh za njegovo dolgoletno kakovostno delo na področju fitomedicine in slovenske znanosti nasploh, se je rodil v Oleščah pri Laškem. Akademik Maček, ki je njegovo 38-letno pedagoško obdobje preživel na današnjem Oddelku za agronomijo Biotehniške fakultete, je eden od najprepoznavnejših slovenskih fitomedicinskih strokovnjakov.

Kar se tiče njegovega raziskovalnega dela v fitomedicini, je deloval na več področjih. V okviru fitopatologije je raziskoval patološko fiziologijo, primarni in sekundarni parazitizem, razvojne kroge parazitskih gliv in njihovo odpornost na sistemične fungicide. Ugotovil je precejšnje število za Slovenijo in prejšnjo državo novih vrst parazitskih gliv in njihovih gostiteljskih rastlin. Pri preučevanju hiponomološke favne v Sloveniji je ugotovil več sto za Slovenijo, prejšnjo državo in jugovzhodno Evropo novih vrst in precejšnje število doslej neznanih gostiteljskih rastlin. Intenzivno je preučeval vpliv raznih skupin herbicidov na talne (tudi parazitske) mikroorganizme. Dolgo je preučeval kontaminacijo rastlin in tal z ostanki fitofarmacevtskih sredstev v Sloveniji in ugotovil sorazmerno skromno obremenitev tako rastlin (pridelkov) kot tal v Sloveniji. Preučeval je tudi ekonomiko varstva rastlin.

Profesor Maček velja za našega najbolj plodovitega pisca strokovne in znanstvene literature s področja fitomedicine. Znanstvenih in strokovnih razprav ter člankov je v tujih in domačih revijah objavil nad 350, raznih krajših strokovnih in poljudno-strokovnih prispevkov pa nad 3000. Akademik Maček je najuspešnejši prevajalec strokovne literature iz biotehniških strok pri nas, izjemnega pomena pa je tudi njegov prispevek k obogatitvi fitomedicinske in biotehniške terminologije nasploh. V obdobju 1984-1994 je objavil 4 univerzitetne učbenike s področja posebne fitopatologije, ki so še danes nepogrešljivo učno gradivo za študente agronomije. Med zadnjimi izvrstnimi knjigami izpod peresa profesor Mačka je

dolga leta pričakovani in leta 2008 izdani učbenik Gozdna fitopatologija. V okviru njegovega bogatega pedagoškega dela, tako na dodiplomskem kot tudi na podiplomskem študiju, je bil mentor okrog sto diplomantom, desetim magistrandom in sedmim doktorandom.

Akademik Maček je bil med najzaslužnejšimi za ustanovitev Društva za varstvo rastlin Slovenije, osrednje domače stanovske organizacije raziskovalcev, svetovalcev in drugih strokovnjakov, ki delajo na področju varstva rastlin in ki danes šteje prek 200 članov. Njegova vloga pri delovanju omenjenega društva in organizaciji vseh dosedanjih devetih posvetovanj je neprecenljiva, saj je bil urednik vseh devetih Zbornikov predavanj in referatov iz posvetovanj, ki so izjemno pomemben vir informacij o varstvu rastlin v Sloveniji v obdobju od leta 1993 do danes in s katerimi se tudi dobesedno piše zgodovina slovenskega varstva rastlin.

Prispevek profesorja Mačka slovenski fitomedicini in znanosti nasploh iz dneva v dan odkrivamo njegovi mlajši sodelavci in smo ponosni, da imamo še vedno čast sodelovati z njim.

Spoštovani profesor, hvala za vse in vse najboljše ob vašem jubileju!

prof. dr. Stanislav Trdan in sodelavci
iz fitomedicinskega dela Katedre za fitomedicino,
kmetijsko tehniko, poljedelstvo,
pašništvo in travništvo

NAVODILA AVTORJEM

Prispevki

Sprejemamo izvirne znanstvene članke, predhodne objave in raziskovalne notice s področja agronomije, hortikulture, rastlinske biotehnologije, raziskave živil rastlinskega izvora, agrarne ekonomike in informatike ter s sorodnih področij v slovenskem, angleškem in nemškem jeziku, znanstveno pregledne članke samo po poprejšnjem dogovoru. Objavljamo prispevke, podane na simpozijih, ki niso bili v celoti objavljeni v zborniku simpozija. Če je prispevek del diplomske naloge, magistrskega ali doktorskega dela, navedemo to in tudi mentorja na dnu prve strani. Navedbe morajo biti v slovenskem in angleškem jeziku.

Pri prispevkih v slovenskem jeziku morajo biti preglednice, grafikoni, slike in priloge dvojezični, povsod je slovenščina na prvem mestu. Naslovi grafikonov in slik so pod njimi. Slike in grafikoni so v besedilu. Priloženi morajo biti tudi jasno označeni izvirniki slik. Na avtorjevo željo jih vračamo, s tem da je želja pisno sporočena ob oddaji gradiva in ponovno v teku 30 dni po izidu. Latinske izraze pišemo ležeče. V slovenščini uporabljamo decimalno vejico, v angleščini decimalno piko. Prispevki v angleščini morajo imeti povzetek v slovenščini in obratno. Prispevki v nemščini morajo imeti tudi povzetka v slovenščini in angleščini.

Prispevki naj bodo strnjeni, kratki, praviloma največ 12 strani. Uporabljamo Microsoft Word 97 (Windows); pisava Times New Roman, velikost strani 16,2 x 23,5 cm, velikost črk besedila 10, v obsežnih preglednicah je lahko 8; izvlečki in metode dela Arial velikost 8, levi in desni rob 2,1 cm, zgornji rob 1,3 cm, spodnji rob 1,6 cm,

Prva stran

Na prvi strani prispevka na desni strani označimo vrsto prispevka v slovenščini in angleščini, sledi naslov prispevka, pod njim avtorji. Ime avtorjev navedemo v polni obliki (ime in priimek). Vsak avtor naj bo označen z indeksom, ki ga navedemo takoj pod avtorji, in vsebuje polni naslov ustanove ter znanstveni in akademski naslov; vse v jeziku prispevka. Navedemo sedež ustanove, kjer avtor dela. Če je raziskava opravljena drugje, avtor navede tudi sedež te inštitucije. Na željo avtorjev bomo navedli naslov elektronske pošte.

Pod naslovi avtorjev je datum prispetja in datum sprejetja prispevka, ki ostaneta odprta. Sledi razumljiv in poveden izvleček z do 250 besedami. Vsebuje namen in metode dela, rezultate, razpravo in sklepe. Sledijo ključne besede.

Izvlečku v jeziku objave sledi naslov in izvleček s ključnimi besedami v drugem jeziku.

Viri

V besedilu navajamo v oklepaju avtorja in leto objave: (priimek, leto). Če sta avtorja dva, pišemo: (priimek in priimek, leto), če je avtorjev več, pišemo: (priimek in sod., leto). Sekundarni vir označimo z "navedeno v" ali "cv.". Seznam virov je na koncu prispevka, neoštevilčen in v abecednem redu. Vire istega avtorja, objavljene v istem letu, razvrstimo kronološko z a, b, c. Primer: 1997a. Navajanje literature naj bo popolno: pri revijah letnik, leto, številka, strani; pri knjigah kraj, založba, leto, strani. Za naslove revij je dovoljena uradna okrajšava, za okrajšanimi besedami naj bodo vedno pike. Navedbo zaključimo s piko. Za primere upoštevajte objave v Zborniku BFUL.

Oddaja

Avtorji prispevke oddajo v dveh izvodih, enega z dvojnim razmakom med vrsticami in največ 35 vrst na strani, in na disketi. Priložijo tudi izjavo s podpisi vseh avtorjev, da avtorske pravice v celoti odstopajo reviji.

Prispevke recenziramo in lektoriramo. Praviloma pošljemo mnenje prvemu avtorju, po želji lahko tudi drugače. Če uredniki ali recenzenti predlagajo spremembe oz. izboljšave, vrne avtor popravljeno besedilo v 10 dneh v dveh izvodih, enega z dvojnim razmakom. Ko prvi avtor vnese še uredniške pripombe, odda popravljeno besedilo v enem izvodu in na disketi ter vrne izvod z uredniškimi popravki.

Prispevke sprejemamo vse leto.

NOTES FOR AUTHORS

Papers

We publish original scientific papers, preliminary communications and research statements on the subject of agronomy, horticulture, plant biotechnology, food technology of foods of plant origin, agricultural economics and informatics; in Slovenian, English and German languages while scientific reviews are published only upon agreement. Reports presented on conferences that were not published entirely in the conference reports can be published. If the paper is a part of diploma thesis, master of science thesis or dissertation, it should be indicated at the bottom of the front page as well as the name of the supervisor. All notes should be written in Slovenian and English language.

Papers in Slovenian language should have tables, graphs, figures and appendices in both languages, Slovenian language being the first. Titles of graphs and figures are below them. Figures and graphs are part of the text. Clearly marked origins of figures should be added; they can be returned if author desires. Latin expressions are written in italics. Decimal coma is used in Slovenian and decimal point in English. Papers in English should contain abstract in Slovenian and *vice versa*. Papers in German should contain abstracts in German, Slovenian and English.

The papers should be condensed, short and usually should not exceed 12 pages. Microsoft Word 97 (Windows) should be used, fonts Times New Roman, paper size 16.2 x 23.5 cm, font size in main text 10; in large tables size 8 could be used, abstracts and material and methods Arial size 8, right and left margin 2.1 cm, upper margin 1.3 cm and lower margin 1.6 cm.

First page

The type of the paper should be indicated on the first page on the right side in Slovenian and English language following by title of the paper and authors. Full names of authors are used (first name and surname). Each name of the author should have been added an index, which is put immediately after the author(s), and contains address of the institution and academic degree of the author, in the language of the paper. The address of the institution in which the author works is indicated. If the research was realised elsewhere, the author should name the headquarters of the institution. E-mail is optional.

Under the address of the authors some space for dates of arrival and acceptance for publishing should be left. A comprehensive and explicit abstract up to 250 words follows indicating the objective and methods of work, results, discussion and conclusions. Key words follow the abstract.

The abstract in the language of the paper is followed by the title, abstract and key words in another language.

References

References should be indicated in the text by giving author's name, with the year of publication in parentheses, e.g. (surname, year). If authors are two, the following form is used: (surname and surname, year). If authors are several, we use (surname *et al.*, year). Secondary literary sources should be quoted in the form "cited in". The references should be listed at the end of the paper in the alphabetical order and not numbered. If several papers by the same author and from the year are cited, a, b, c, etc. should be put after the year of the publication: e.g. 1997a. The following form of citation is used: for journals volume, year, number, page; for books place of publication, publisher, year, pages. For journals official abbreviated forms can be used. A full stop should be put after the abbreviated words. Each reference is also closed by a full stop. Examples are in previous issues.

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Papers should be delivered in two copies, double-spacing and 35 rows per page are required, and on a diskette. A statement signed by all authors transfers copyrights on the published article to the Journal.

Papers are reviewed and edited. First author receives a review. If reviewers suggest some corrections, the author should forward them in 10 days and in two copies, one of them with double space. After the first author considers the editor’s notes, the corrected paper should be sent in one copy and on a diskette.

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