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ANALYSES OF LETTUCE (*Lactuca sativa* L.) PRODUCTION, COMPARING CONVENTIONAL, INTEGRATED AND ORGANIC CROP MANAGEMENT

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ABSTRACTS

The goal of this research was to determine the influence of alternative systems of crop management (organic and integrated) and endomycorrhiza on vegetative growth and yield of lettuce.
During 2002 two-factor trial with three repetitions and split-plot design was set up in Pula. Main factor "crop management" had three levels (organic, integrated and conventional) while the sub factor "mycorrhiza" had two levels (lettuce seedlings inoculated with endomycorrhizal fungus and non-inoculated seedlings). On plots assigned for organic crop management, pea plants grown on the plots before the lettuce were mowed and used as mulch. Other plots were mulched with black polyethylene film. Lettuce seedlings were planted with root ball; fertilization and cultivation measures were performed according to basic principles of organic, integrated and conventional crop management system.
The biggest diameter of heads had lettuce from integrated crop management system (17% bigger than lettuce from organic system). Inoculated plants also had 6% bigger diameter than non-inoculated. Marketable heads from integrated system achieved 13% bigger mass than lettuce from conventional system and 30% bigger than plants from organic system. The biggest yield of lettuce was achieved with integrated crop management (35.51 t/ha) and it did not statistically differ from the yield from conventional crop management (31.05 t/ha). Both systems had significantly bigger marketable yield compared with organic crop management (21.65 t/ha).

Key words: conventional crop management, endomycorrhiza, integrated crop management, lettuce (*Lactuca sativa* L.), organic crop management.

IZVLEČEK

ANALIZA PRIDELAVE SOLATE (*Lactuca sativa* L.) S PRIMERJAVO KONVENCIONALNEGA, INTEGRIRANEGA IN ORGANSKEGA NAČINA

Raziskave Bulluck *et al*. (2002) in Elliot in Mumford (2002) kažejo, da je poleg konvencionalne pridelave zelenjave mogoča tudi pridelava v alternativnih sistemih, ki so za okolje manj tvegani, hkrati pa dajejo zadovoljive gospodarske rezultate. Namen te raziskave je bil, določiti vpliv alternativnih sistemov pridelave (organski in integrirani) ter vpliv endomikorize na vegetativno rast in pridelek solate. V letu 2002 smo v Pulju izvedli dvofaktorski poskus, s 3 ponovitvami in split-plot metodo. Glavni faktor (način pridelave) je imel 3 ravni (organski, integrirani, konvencionalni), podfaktor mikoriza je imel 2 ravni (sadike solate inokulirane z endomikorizno glivo *Glomus mossae* in neinokulirane sadike). Na parcelah določenih za organsko pridelavo, je pred solato rasel grah, rastline so bile pokošene in uporabljene za zastor. Druge parcele so bile pokrite s črno polietilensko folijo. Sadike solate cv. Vanity so bile posajene s koreninsko grudo, gnojenje in obdelovanje je potekalo v skladu s temeljnimi načeli organske, integrirane in konvencionalne pridelave. Način pridelave in mikoriza nista vplivala na gostoto rastlin. Največji premer glav solate je bil v integrirani pridelavi (17 % večje kot v organski pridelavi). Inokulirane sadike so imele za 6 % večji premer glav kakor neinokulirane. Tržni pridelek glav solate v integrirani pridelavi je dosegel 13 % večjo maso kot v konvencionalni pridelavi in 30 % večjo kot v organski pridelavi. Mikoriza ni vplivala na povprečno maso tržnega pridelka. Največji pridelek solate je bil v integrirani pridelavi

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(35,51 t/ha) in se ni statistično značilno razlikoval od pridelka v konvencionalni pridelavi (31,05 t/ha). V obeh sistemih je bil tržni pridelek statistično značilno večji od pridelka v organski pridelavi (21,65 t/ha). Mikoriza ni vplivala na pridelek. Način pridelave in mikoriza nista vplivala na odstotek netržnih rastlin.

Ključne besede: konvencionalna pridelava, endomikoriza, integrirana pridelava, solata (*Lactuca sativa* L.), organska pridelava.

1 INTRODUCTION

Profitable conventional vegetable production is characterized by a high degree of chemization, highly specialized farms and a high production with high input of means and materials to increase the yield and decrease the costs per unit area (Abdul-Baki, 1998). Such production inevitably requires actions, which pose a risk to the environment and human health, and lead to soil degradation (Bašić, 1996). Recent research (Novak, 1997; Gaskel *et al.*, 2000; Ban, 2001; Bulluck *et al.*, 2002; Elliot and Mumford, 2002) suggests possible alternative systems in vegetable production, which are less risky for the environment but with satisfactory economic effects. The objective of this research was to determine the effect of alternative production systems (organic and integrated) and endomycorrhiza on the vegetative growth and yield of the lettuce (*Lactuca sativa* L.) in comparison with the conventional system.

2 MATERIALS AND METHODS

The research was conducted on a family farm in Pula during 2002. A two factorial trial was set up in split-plot design with 3 replications. The main factor, "production system", had three levels (organic, integrated and conventional) and the size of a main plot was 45 m^2 (10 m x 4.5 m). The sub factor, "mycorrhiza", had two levels (lettuce transplants inoculated with endomycorrhizal fungus *Glomus mossae* and non-inoculated transplants) and the size of a split plot was 22.5 m^2 (5 m x 4.5 m).
The soil had neutral reaction (pH 7.07 in MKCl), it contained 2.3 % humus, 3.49 mg P_2O_5/100 g of soil and 17.95 mg K_2O /100 g of soil. The soil for all production systems was ploughed in February to a depth of 30 cm. On the plots assigned for the organic production system, stable manure (100 m^3/ha) was ploughed in. After additional soil tillage, stock pea (140 kg/ha) was sown on plots assigned for organic production and it was than cut in the mid-June and left as cover crop mulch. At the same time the plots for integrated and conventional production systems were prepared as follows: fertilization was performed with a complex mineral fertilizer (1000 kg/ha NPK 7-20-30), herbicide was applied (trifluralin, 2 l/ha), and the drip irrigation system and black PE mulch (1.2 m of width) were installed.
Lettuce transplants of the culitvar Vanity, grown in polystyrene containers with 150 pots (sowing date: June, 3) were planted in the phase of 5 to 6 true leaves (8 July) on three plots, that is, four-row strips per plot. The distance between the rows was 25 cm as well as the distance between the plants in the row while the distance between the beds was 50 cm (10.67 plants/m^2). The middle strip was used for all of the measurements. Irrigation was performed using drip irrigation. Fertilization and basic crop cultivation measures during vegetation were conducted dependent on the production system (table 1 and 2).

Protection from disease and pests in the ecological system was performed with remedies permitted by the "Rulebook on ecological production of plants and in total production of plant's products" (Official Gazette No. 91/2001).

The harvest of lettuce was done on August 25 for all production systems. After the harvest, plant distance was determined as well as diameter of heads, average mass of heads, yield and percentage of non-marketable lettuce heads.
Statistical analysis of the effect of the main factor, sub factor and their interaction on the observed characteristics was conducted by applying the analysis of variance (F-test), while the differences between the average values of the main factor and the interaction were tested by the Duncan's Multiple Range Test ($p \leq 0.05$).

Table 1: Fertilization regime per production system

Fertilizer	Production system		
	Organic	Integrated	Conventional
Farmyard manure	100 m^3/ha	-	-
Mineral fertilizer (NPK 7-20-30)	-	1000 kg/ha (70 kg N/ha)	1000 kg/ha (70 kg N/ha)
Soluble mineral fertilizer (NPK 19-6-20)	-	88 kg N/ha in two portions (every second week from July, 25)	158 kg N/ha in four portions (every week from July, 25)
Total kg N/ha	From farmyard manure~150	158	228

Table 2: Pesticide use per production system

Pesticide name	Production system		
	Organic	Integrated	Conventional
Limacide:			
- Metaldehyde (Limax M)	1 x (30 kg/ha)	1 x (35 kg/ha)	1 x (40 kg/ha)
Insecticides:			
- Chlorpyrifos ethyl (Dursban G-7.5)	-	1 x (15 kg/ha)	1 x (20 kg/ha)
- Deltametrin (Rotor 1.25 EC)	-	2 x (0.06 %)	2 x (0.06%)
- Pyrethrum extract (Biotox P)	2 x (~ 600 l/ha)	-	-
- Yellow boards	1 200 piece/ha	-	-
Fungicides:			
- Metalaxyl+mancozeb (Ridomyl MZ 72 WP)	-	-	1 x (0.30 %)
- Tolylfluanid (Euparen multi)	-	1 x (0.25 %)	1 x (0.25 %)
- Iprodion (Rovral SC)	-	1 x (0.30 %)	2 x (0.30 %)
Herbicides:	2 x weeding	-	-
- Trifluralin (Treflan EC)	-	1 x (2 l/ha)	1 x (2 l/ha)
- Glufosinate-amonium (Basta 15)	-	1 x (6 l/ha)	1 x (6 l/ha)

3 RESULTS AND DISCUSSION

Production system and mycorrhiza as well as their interaction had no effect on the reduction of plant density in lettuce (table 3). Reduction of plant density in lettuce is caused mainly by slugs that are causing major damages immediately after planting.
Since limacide (Metaldehyde) was used in all three systems of production and the weather conditions were not favorable for slugs their attack was minimal. Therefore, reduction in plant distance from 11 to 18 % was mainly caused by high temperatures immediately after planting.

Table 3: Effect of production system and mycorrhiza on the achieved plant density of lettuce (number of plants/ m^2) in the time of harvest, Pula, August 5, 2002

Production system	Mycorrhiza	Without mycorrhiza	Production system average
Organic	9,20 N.S.[1]	8,80 N.S.	**9.00 N.S.**[2]
Integrated	8,98 N.S.	9,15 N.S.	**9,07 N.S.**
Conventional	9,51 N.S.	9,49 N.S.	**9,50 N.S.**
Average "mycorrhiza"	**9,23 N.S.**[3]	**9,15 N.S.**	

[1,2]Duncan`s Multiple Range test (P=0,05) for interaction "production system" x "mycorrhiza" and for factor "production system", [3]justifiable F-test (P=0,05) for sub factor "mycorrhiza", N.S.-not significant

The biggest diameter had lettuce grown according to the principals of integrated crop management that had 17 % and 5 % more diameter than lettuce grown in organic and conventional system, respectively (table 4). Inoculated lettuce had 6 % bigger diameter than non-inoculated plants. Interaction between two investigated factors also had influence on diameter of lettuce heads (table 4). The biggest diameter had inoculated plants of lettuce grown in integrated production system (36.1 cm), while the smallest diameter was recorded on non-inoculated plants in organic production system. Plants grown in organic system developed more slowly than those from other two systems of crop management so it was logical to expect that they would have smaller diameter of heads. Inoculation of plants probably assisted in receiving of the nutrients since the soil was at the beginning poorly provided with the nutrients and therefore non-inoculated plants developed more intensively than non-inoculated.

Table 4: Influence of production system and mycorrhiza on diameter of lettuce heads (in cm), Pula, August 25, 2002

Production system	Mycorrhiza	Without mycorrhiza	Production system average
Organic	31,3 C[1]	27,1 D	**29,0 B**[2]
Integrated	36,1 A	34,4 AB	**35,3 A**
Conventional	33,5 BC	33,3 BC	**33,4 AB**
Average "mycorrhiza"	**33,7 A**[3]	**31,6 B**	

[1,2]Duncan`s Multiple Range test (P=0,05) for interaction "production system" x "mycorrhiza" and for factor "production system", [3]justifiable F-test (P=0,05) for sub factor "mycorrhiza"

Lettuce grown according to the principles of integrated crop management had significantly bigger head mass (13 and 30 % more) than lettuce grown in conventional and organic production system, respectively (table 5). Mycorrhiza as well as interaction of mycorrhiza and production system did not influence the mass of marketable lettuce heads.

Table 5: Influence of production system and mycorrhiza on average mass of marketable lettuce heads (g), Pula, August 25, 2002

Production system	Mycorrhiza	Without mycorrhiza	Production system average
Organic	347 N.S.[1]	333 N.S.	**340 C**[2]
Integrated	497 N.S.	467 N.S.	**480 A**
Conventional	427 N.S.	417 N.S.	**422 B**
Average "mycorrhiza"	**423 N.S.**[3]	**406 N.S.**	

[1,2]Duncan`s Multiple Range test (P=0,05) for interaction "production system" x "mycorrhiza" and for factor "production system", [3]justifiable F-test (P=0,05) for sub factor "mycorrhiza", N.S.-not significant

The mass of heads is connected with the plant development that is, apart from other factors, under the influence of nutrition, which is visible on the mass of plants from organic production system.

Lettuce grown in organic production system had 3,59%, and 1,82% more non-marketable heads than lettuce grown in integrated and conventional production system, respectively (table 6). However, that difference was not statistically justified. There was also no statistically justifiable difference between inoculated and non-inoculated plants. The differences determined between combinations of interactions were also not statistically confirmed. Non-marketable heads are primarily caused by pests and diseases but since the

summer weather did not soothe them there was no significant difference between the treatments.

Table 6: Influence of production system and mycorrhiza on proportion of non-marketable lettuce heads (%), Pula, August 25, 2002

Production system	Mycorrhiza	Without mycorrhiza	Production system average
Organic	9,25 N.S.[1]	6,97 N.S.	**8,11 N.S.**[2]
Integrated	4,60 N.S.	4,44 N.S.	**4,52 N.S.**
Conventional	6,31 N.S.	6,27 N.S.	**6,29 N.S.**
Average "mycorrhiza"	**6,72 N.S.**[3]	**5,90 N.S.**	

[1,2]Duncan`s Multiple Range test (P=0,05) for interaction "production system" x "mycorrhiza" and for factor "production system", [3]justifiable F-test (P=0,05) for sub factor "mycorrhiza", N.S.-not significant

Lettuce yield in organic production system was by 64% lower compared with integrated and by 43% lower compared with conventional production system (table 7).

Table 7: Influence of production system and mycorrhiza on marketable lettuce yield (t/ha), Pula, August 25, 2002

Production system	Mycorrhiza	Without mycorrhiza	Production system average
Organic	22,58 N.S.[1]	20,71 N.S.	**21,65 B**[2]
Integrated	36,22 N.S.	34,80 N.S.	**35,51 A**
Conventional	30,98 N.S.	31,11N.S.	**31,05 A**
Average "mycorrhiza"	**29,92 N.S.**[3]	**28,88 N.S.**	

[1,2]Duncan`s Multiple Range test (P=0,05) for interaction "production system" x "mycorrhiza" and for factor "production system", [3]justifiable F-test (P=0,05) for sub factor "mycorrhiza", N.S.-not significant

However, difference between conventional and integrated crop management was not statistically confirmed. There was also no statistical difference between the yield of inoculated and non-inoculated plants. The biggest influence on the yield probably had fertilization that was best balanced in integrated crop management system while in organic management system, little quantity of nutrients probably caused starvation of plants on certain elements. Interaction between crop management system and mycorrhiza was not determined.

4 CONCLUSIONS

Based on one-year research, for summer production of lettuce, cultivation based on integrated crop management system is advisable as ecologically acceptable and as optimal system of cultivation.
Organic production system of lettuce in summer is possible but reduction of yield is to be expected.
Mycorrhiza is not advisable in summer production of lettuce.

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