4 CONCLUSIONS

The most imporant factors that reduce the productivity of the watermelon are high temperatures, high humidity, exces rain, pests and diseases. The results obtained in our study indicate that the use of different mulch system is a potential factor in aphids control on watermelons.

The aphids' flight maximum in watermelon growth at Pula in 2008 was occurred two weeks earlier than at Opuzen (2004, 2005). Ten days after the planting, during the first assessment, the aphid population density was equally as the recorded maximum. That indicates the observations of the visual traps are necessary, anon after the planting, in order to create the aphids control management strategy.

The effect of different mulches on aphid populations in vegetable crops has to be continued.

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Changes in floristic composition over three years of Ljubljana marsh grassland in relation to cutting and fertilising management

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ABSTRACT

A research in Ljubljana marsh was conducted from 2004 to 2006 with the aim to determine how the regime of cutting and fertiliser application over several years influences on the floristic composition of meadow sward. Field sampling plots in split-plot design with four replications were set up on two different types of grassland, one belonging to *Arrhenatherion* (sampling plot T1), the other to *Molinion* alliances (sampling plot T2) in 1999. The main plots represented the frequency of 4 cutting regimes (2 cuts with normal and delayed first one, 3 and 4 cuts per year) and sub-plots represented the fertiliser regime (no fertiliser, PK and NPK fertiliser with two different amounts of N). After five years, the cutting, and especially fertiliser application, significantly altered the floristic composition. In floristic composition of *Arrhenatherion* plot more frequent cutting in combination with higher amount of N fertilisation increased the proportion of grasses (92.7 % on a fresh matter basis). This was mostly observed in 2004. Legumes proportion (15.4 %) increased mainly on plots where PK fertiliser was used and a first cut was retarded. When N fertiliser was used on *Molinion* plot in all treatments with cutting herbs (forbs) increased their proportion up to 65 % in average. The proportion of legumes in sward of this plot was neglecteable that's way treatments did not have any special effect on them.

Key words: Ljubljana marsh, grassland, cutting, fertilising, floristic composition, biomass

IZVLEČEK

SPREMEMBE V FLORISTIČNI SESTAVI RUŠE LJUBLJANSKEGA BARJA SKOZI TRI LETA V ODVISNOSTI OD ČASA KOŠNJE IN INTENZIVNOSTI GNOJENJA

Na Ljubljanskem barju smo v obdobju 2004-2006 opravili raziskavo, s katero smo želeli ugotoviti, kako vplivata število košenj in gnojenje skozi daljše obdobje na floristično sestavo ruše. Travniška poskusa v split-plot zasnovi s štirimi ponovitvami sta bila zasnovana na dveh tipih poskusnih ploskev, ki pripadata zvezama *Arrhenatherion* in *Molinion* v letu 1999. Glavne parcele so predstavljale štiri režime pogostnosti košnje (2-kosna raba z zapoznelo in standardno prvo košnjo, 3-kosna in 4-kosna raba), podparcele pa način gnojenja (negnojeno, gnojeno z gnojili PK in NPK, gnojeno z dvema različnima odmerkoma N). Po petih letih sta košnja in predvsem gnojenje zelo spremenili videz travišča in vplivala na floristične karakteristike travne ruše. V travni ruši poskusnih ploskev zveze *Arrhenatherion* je pogostejša košnja v kombinaciji z večjim odmerkom dušika vplivala na večji delež trav (92,7 % v svežem zelinju). Ta sprememba je bila najbolj izražena v letu 2004. Delež mase metuljnic (15,4 %) se je najbolj povečal po gnojenju s PK in zapoznelo prvo košnjo. Na poskusni parceli zveze *Molinion* se je najbolj povečal delež zeli (največ 65 %), in sicer v vseh postopkih košnje ter tedaj, kadar je bil uporabljen dušik. Delež metuljnic v tej ruši je bil zanemarljiv.

Ključne besede: Ljubljansko barje, travinje, košnja, gnojenje, floristična sestava, biomasa

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1 INTRODUCTION

The Slovene grasslands, predominantly existing as semi-natural vegetation, cover 60 % of agricultural land (5000 km^2) (Čop, 2006). In addition 2700 km^2 of abandoned grasslands have reached different phases of plant succession toward forest climax vegetation for the last fifty years. On the managed grasslands the cutting system prevails with two to three cuts on mesotrophic, and one cut on oligotrophic karst and wet grasslands. Intensive cutting and grazing systems were also introduced on many farms during last few decades. Due to this development and abandoning of herbage production in marginal grassland areas many species-rich meadows and mountain pastures are endangered (Čop *et al.*, 2004). In temperate climate zone grassland management is a key factor which determines sward floristic composition (Hopkins and Holz, 2005). Generally, intensification of herbage production reduces sward plant diversity while improving its agronomic value (Plantureux *et al.,* 2005). Grasslands in marginal areas can be exception to this and preservation of the remaining species-rich grassland is a primary goal of nature conservation (Armbruster and Elsäßer, 1997; Mountford *et al*., 1993) The continuation of traditional ways of grassland management that would best preserve biodiversity is often not compatible with the requirements of intensive livestock production (Isselstein *et al.*, 2005; Critchley *et al*., 2002; Hopkins *et al*., 1990). Therefore, we have been performing a long term field study to investigate effects of cutting regime and fertiliser inputs on sward floristic composition of two grassland types located in an environmentally sensitive area such as Ljubljana marsh area (Seliškar, 2000; Jogan *et al.*, 2004; Hacin *et al.*, 2001). Almost all grasslands represent unimproved and semi-improved hay meadows traditionally mowed twice a year. In the past there was also a combination of lax spring and autumn grazing along with summer cutting (Verbič, 2000). Undesired plant succession has occurred on many parts of Ljubljana marsh, area that can be assigned as typical environmentally sensitive one. Of its 160 km^2 surface app. 120 km^2 are covered by semi-natural grassland, which is highly diverse, often supporting considerable floristic diversity at a local scale, providing habitats for invertebrate and other animal groups and delivering a range of ecosystems and socio-economic functions. On this Ljubljana marsh *Arrhenatherion* alliance is a dominant vegetation. Much less grassland area belongs to *Molinion*, *Filipendulion*, *Magnocaricion*, *Caricion davallianae* and *Phragmition communis* alliances (Seliškar, 1986). Aiming for sustainable grassland production in this area, a research was conducted to test the effects of cutting and fertiliser treatments on herbage production and floristic composition of *Arrhenatheretum elatius* and *Molinia caerulea* grasslands. We wanted to test the influence of two typical grassland management measures on floristic changes in meadow sward.

2 MATERIAL IN METHODS

In March 1999, two sampling plots were established on semi-natural grassland of Ljubljana marsh (lat. 45°58' N, long. 14°28' E, alt. 295 m). One plot was on grassland with predominant *Arrhenatherum elatius* (T1) and the other on fen meadow with predominant *Molinia caerulea* (T2). Both plots were arranged in split-plot design with four replications. Three cutting regimes were allocated as the main plots and four fertiliser treatments as sub-plots. Cutting regimes for T1 were: 2 cuts with delayed first one, 3 cuts and 4 cuts per year, and for T2 were: 2 cuts with a 'normal' and delayed first one and 3 cuts per year. Fertiliser treatments were 0 NPK (= no), 35 kg P + 133 kg K $ha^{-1}yr^{-1}$ (= PK), 50 kg N $ha^{-1}cut^{-1}$ applied to the first cut only + 35 kg P + 133 kg K ha^{-1} yr^{-1} (= $N_{(1)}$PK) and 50 kg N ha^{-1} cut^{-1} applied to each of 2 or 3 or 4 cuts + 35 kg P + 133 kg K ha^{-1} yr^{-1} (=$N_{(c)}$PK). The sub-plot size was 2.5 × 4 m in T1, and 2 × 4 m in T2 (Čop *et al.*, 2001). In the fourth trial year (2002), the soil was moderately acid (pH/$CaCl_2$ = 4.9 – 5.2) with low to moderate P and moderate to high K content (P = 1.9 – 5.5 mg, K = 10.6 – 29.5 mg) in T2. Fertilising with PK in previous years had a positive effect on soil nutrient status only on *Molinia caerulea* fen meadow (T2 sampling plot). The chemical properties of soil on *Arrhenatherum elatius* grassland (T1 sampling plot) in four most intensive treatments in the eight year are shown in Table 1.

***Table 1**: Chemical properties of soil on four plots of sampling plot T1 in spring 2006 after 7 years of experiment (phosphorus and potash were determined by extraction in ammonium lactate).*

Treatment		pH/$CaCl_2$	P_2O_5/(mg/100 g)	K_2O/(mg/100 g)
four cut regime	no	7.0	3.5	11.8
	PK	6.9	14.9	21.1
	$N_{(1)}$PK	7.0	10.9	16.2
	$N_{(c)}$PK	6.9	15.6	16.4

Results presented here are derived from the first cut of the sixth, seventh and eight trial years and comprise proportions of floristic groups (grasses belonging to botanical family *Poaceae*, legumes belonging to botanical family *Fabaceae* and herbs belonging to remaining botanical families) in herbage. The analyses were performed by means of hand separation of fresh herbage samples into plant floristic groups which were afterwards weighted. The size of sampling area was 0.5 × 0.8 m. According to Braun-Blanquet method (1964) a floristical survey on species presence (a combine assesment of cover and abundance) was also conducted. Statistical analyses of data were done by ANOVA and only p values (significance level) are shown for both factors and their interaction. Data in proportions were transformed using an equation Y = 2*arcsine(sqrt(x)). Results for ANOVA are presented only for the eight (2006) trial year.

3 RESULTS

In 2006, we made a floristical survey at all 96 sub-plots (3 cutting regimes, 4 fertiliser treatments regimes, 4 replications) of sampling plots T1 and T2. The community of *Arrhenatherum elatius* grassland consisted in total of 89 species (Table 3), from most abundant to rare ones. The most frequent grasses were *Arrhenatherum elatius*, *Festuca rubra* and *Dactylis glomerata*. The group of legumes was represented by *Vicia cracca*, *Lathyrus pratensis* and *Trifolium pratense* whereas *Equisetum palustre*, *Galium mollugo* and *Ranunculus repens* prevailed in a group of herbs. The community of *Molinia caerulea* consisted in total of 85 species (Table 4). Three most frequent grasses were *Molinia caerulea, Anthoxanthum odoratum* and *Holcus lanatus*. From a group of legumes the most frequent were *Vicia cracca*, *Lotus uliginosus* and *Lotus corniculatus*, meanwhile the group of herbs was represented the most frequently by *Filipendula ulmaria*, *Galium mollugo* and *Potentilla erecta*. In sampling plot T1 a higher management intensity (special with four cuts per year and applying 50 kg of N at each cut) encouraged the group of grasses (Figure 1; bigger circles in ternary graphs), which is most noticeabled in year 2005. The highest fresh herbage proportion of grasses (92.7 %) was measured on plot with treatment of three cuts and N_{50}PK fertiliser in 2005. The highest proportion of legumes (15.4 %) was determined on plot with treatment of two cuts with delayed first cut and PK fertiliser in 2006 and the highest proportion of herbs (49.4 %) was measured on plot with treatment of two cuts with delayed first cut and no fertiliser in 2004. Cutting regimes had significant effect on proportion of grasses and legumes, fertiliser treatments had only on legumes and none of them on herbs proportion (Table 2). Due to the lack of legumes (important ones) in the sward none of the treatments came near to the recommended proportion of floristic groups (Fig. 1: triangle symbol in ternary graphs) in sward of semi natural grassland when looking from the forage production view (Dietl, 1982).

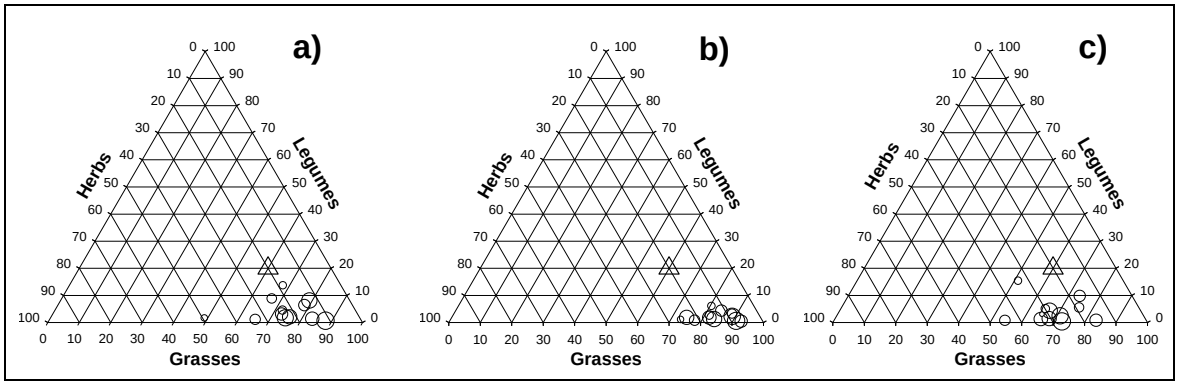

***Figure 1**: Influence of cutting and fertiliser application on floristic composition of Arrhenatherion sampling plot (T1) in 2004 (a), 2005 (b) and 2006 (c) (o-most extensive management, ○-most intensive management) (4 cuts) and position of optimal proportion (△) of floristic groups in semi natural grassland.*

In sampling plot T2, a lack of legumes in sward was even more expressed. However sward on plots which received only PK fertiliser showed the increase in proportion of legumes and this fact led to the highest proportion of them (11.4 %) on plot with treatment of two cuts and PK fertiliser in 2005. On the other hand, with increasing intensity of management (specially with N fertiliser) of herbs (Figure 2; year 2005) which

resulted in their highest proportion of herbs (85.0 %) on plot with treatment of two cuts and delayed first cut and applying 50 kg of N at each cut in 2004. Grasses reached the highest proportion (88.7 %) on plot with treatment of two cuts and no fertiliser in 2005.

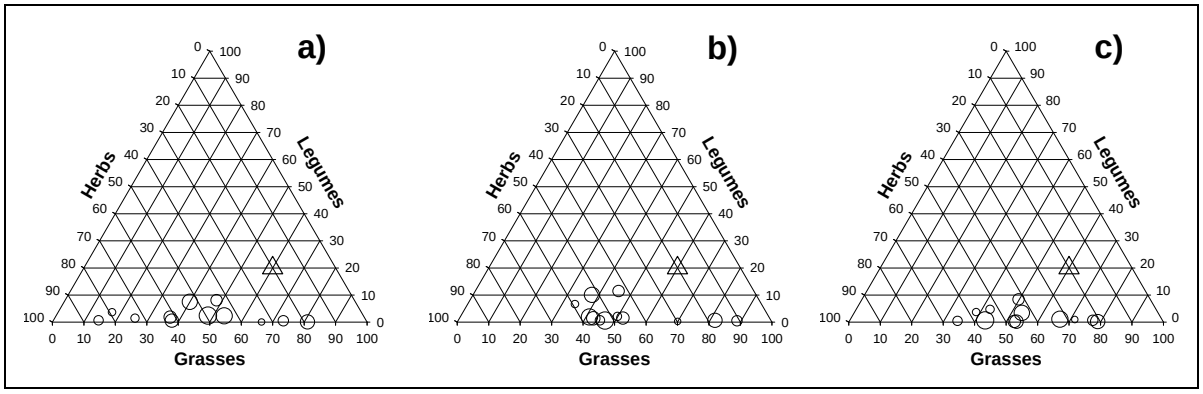

***Figure 2**: Influence of cutting and fertiliser application on floristic composition of Molinion sampling plot (T2) in 2004 (a), 2005 (b) and 2006 (c) (o-most extensive management, ○-most intensive management) (4 cuts) and position of optimal proportion (△) of floristic groups in semi natural grassland.*

The proportion of floristic groups on sampling plot T2, measured in eight year, first cut, was affected less by cutting than fertiliser application (Table 2). Interaction between cutting regime and fertiliser treatments had no significant effect on none of the floristic groups.

***Table 2**: Significance level (alpha risk) for the test of effects of the cutting regime (C) and fertiliser treatments (F) on floristic groups in herbage of the 1st cut in Arrhenatherion (T1) and Molinion (T2) sampling plots, 8th trial year.*

	Sampling plot T1			Sampling plot T2		
	Grasses	Legumes	Herbs	Grasses	Legumes	Herbs
Cutting regime (C)	0.002	0.033	0.455	0.041	0.454	0.064
Fertiliser treatments (F)	0.127	<0.001	0.117	0.001	<0.001	0.001
C x F	0.072	0.468	0.080	0.920	0.100	0.915

Table 3: Floristical survey of the *Arrhenatherum elatius* grassland after Braun-Blanquet method (sampling plot T1) according to cutting regime and fertilising (8th trial year) *.

	2 cuts (delayed)				3 cuts				4 cuts			
	no	PK	N_lPK	N_cPK	no	PK	N_lPK	N_cPK	no	PK	N_lPK	N_cPK
Anthoxanthum odoratum								1	+	+	+	+
Arrhenatherum elatius	2	2	2	3	+	3	3	3	+	2	1	3
Dactylis glomerata	1	+	+	1	+	1	1	1	+	1	1	1
Festuca pratensis	+	+			1	1	1	1		1	1	+
Festuca rubra agg.	2	1	1	+	2	1	1		3	1	3	+
Helictotrichon pubescens			+	+	2	1	2	2	1	1	1	1
Holcus lanatus	+	1	1	+							+	
Poa trivialis	+						+	+				1
Lathyrus pratensis	+	1	+	+		+		+				
Medicago lupulina		+								+		+
Trifolium pratense		+			1	1	1					+
Vicia cracca	+	+		+	+	+	+	+		+	+	+
Achillea millefolium	+	+	+	+	1	+	2	1	+	+	+	1
Ajuga reptans					+				+			+
Angelica sylvestris		+				+	+			+		
Calystegia sepium		+	+	+			+					
Campanula patula	+		+	+		+	+			+		
Centaurea jacea	+	+	+	+	+	+	+	1	+	+	1	+
Cerastium holosteoides								+			+	+
Cirsium oleraceum		+	+				+				+	
Convolvulus arvensis	+	+	+	+		+	+			+		+
Cruciata glabra		+	+	+		+				+		
Daucus carota	+		+	+	+			+				
Equisetum palustre	3	1	1	+	3	1	+	+	3	+	+	+
Erigeron annuus							+	+		+		
Galium mollugo	1	2	2	2	1	2	1	2	1	+	+	1
Glechoma hederacea				+		+						+
Leontodon hispidus	+				+	+			+	+		
Leucanthemum ircutianum	+	+	+	+	+	+	+	+	+	1	2	+
Lythrum salicaria	+	+		+	+		+					
Silene latifolia		+		+	+	+	+	+				
Mentha aquatica	+	+				+			+			+
Mentha longifolia			+	+				+				
Pastinaca sativa	+	+	+	+	+		+	+				
Pimpinella major	+	+	+							+	+	
Plantago lanceolata	+				1	+	1	1	1	+	+	+
Ranunculus acris	+	+			1		1	1	+	+	+	+
Ranunculus repens	+	+	+	+	+	+	+	+	+	+	+	+
Rumex acetosa							+	+	+		+	
Taraxacum officinale								+	+	+		+
Verbascum sp.				+		+	+		+			
Veronica persica	+			+			+		+	+	+	+
Total number of species	29	27	22	29	24	26	30	30	28	25	24	28

* Species with cover < 1 %, appeared in one or two treatments only, are not included in the table.

***Table 4**: Floristical survey of the Molinia caerulea fen meadow after Braun-Blanquet method (sampling plot T2) according to cutting regime and fertilising (8th trial year)*.*

	2 cuts (delayed)				2 cuts				3 cuts			
	no	PK	N_1PK	N_2PK	no	PK	N_1PK	N_2PK	no	PK	N_1PK	N_2PK
Anthoxanthum odoratum	1	1	+	+	1	+	+	1	1	1	1	1
Arrhenatherum elatius				1		+	+					
Brachypodium pinnatum		2	2	+	+	2	2	2	+	+	1	
Briza media	+	+	+		+	+	+		+	+	+	
Carex flava	+				+	+			+	+	+	+
Dactylis glomerata						+	+	1		1		
Deschampsia cespitosa										+		1
Festuca ovina agg.									+	1		
Festuca pratensis		+	+	+		+	+	2			+	+
Festuca rubra agg.		1	+	1		1	1	1	1	2	2	2
Helictotrichon pubescens		+				+	2				+	+
Holcus lanatus	+	1	2	1	+	1	1			+	1	
Luzula campestris	+	+			+				+	+	+	
Molinia caerulea	4	+	+	+	4	+			3	+	+	+
Lotus corniculatus	+	1	+									
Lotus uliginosus	+	1	+		+	1			+	1	+	
Vicia cracca		1		+	1	+	+	+	+	+	+	+
Angelica sylvestris	+	+	+	+		+	+	+	+	+	+	+
Betonica officinalis	+	+	+	+	+	+	+	1	+	+		+
Centaurea jacea		+	+						+	+	+	+
Cirsium oleraceum										+	+	+
Cruciata glabra		+	+							+	+	+
Daucus carota												+
Equisetum palustre									1	+		
Filipendula ulmaria	2	1	1	2	1	1	2	1	1	+	1	1
Galium mollugo	+	1	1	2	2	2	1	3	1	1	2	2
Leucanthemum ircutianum	+	+	+	+				+		1	1	1
Lysimachia vulgaris		+										
Lythrum salicaria	+	+	+	+			+		+	+	+	
Plantago lanceolata		+	+	+	+	+		+	+	+	+	+
Potentilla erecta	1	+	+	+	+	+	+	+	1	+	+	+
Ranunculus acris	+	+			+					+	+	
Ranunculus repens	+	+								+	+	+
Rumex acetosa		+	+			+	+	+				+
Thymus alpestris	+				+				+	+	+	+
Total number of species	21	26	20	18	18	22	19	15	26	36	28	25

* Species with cover < 1%, appeared in one or two treatments only, are not included in the table.

4 DISCUSSION

In this study, we explored the possibility of combining agricultural and nature conservation objectives in threatened wet grasslands at the Ljubljana marsh by applying different cutting regimes and fertiliser amounts. Both factors were tested at low (no for fertiliser) to moderate levels to confirm their effects on the floristic composition of two seminatural unimproved meadows. After eight trial years the data show that the NPK and PK fertilising treatments improved floristic composition on T1 sampling plot regarding fodder quality, while on T2 sampling plot these two treatments increased the proportion of herbs, which are not the most appropriate for the nutrient poor grassland community as the one belonging to *Molinion* alliance. Grasses, especially the competitive *Arrhenatherum elatius*, *Dactylis glomerata* and *Festuca pratensis*, responded to moderate increasing number of cuts and fertiliser input with an increase in their proportion in the

sward of sampling plot T1. This response is considered as typical and is described elsewhere (e.g. Tallowin, 1996; Wyss, 2002). Under similar treatment conditions, the stress tolerant *Molinia caerulea*, which initially prevailed in the sward of sampling plot T2, was replaced mainly by forbs (*Filipendula ulmaria* within delayed 2 cuts and *Plantago lanceolata* and *Galium mollugo* within other two cutting regimes) (Čop *et al*., 2004). Every fertiliser input increased proportion of tall grasses belonging to *Arrenatherum elatius* grassland and tall forbs belonging to *Molinia caerulea* fen meadow as was also got in the literature (Smith *et al*., 1996). But we should also not forget that amount of precipitation and solar radiation can have significant effect on grassland production. And also floristic composition of sward is only one variable in multi dimensional space in which other two important variables are dry matter yield (quantity) and nutrients yield (quality). For the last two it is known for a long time that they increase with management intensity of grassland sward.

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