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Weed suppression ability of spring cereal crops and peas in pure and mixed stands

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Abstract. Weeds were investigated in the stands of field pea (*Pisum sativum* L.), barley (*Hordeum vulgare* L.), wheat (*Triticum aestivum* L.), oat (*Avena sativa* L.) and triticale (*Triticale hexaploide* Lart.) grown as pure and as mixtures at the Lithuanian Institute of Agriculture. Results revealed that annuals dominated in the weed flora composition (7–19 species) while perennials were more recessive (2–11 weed species). The total weed number was higher by 1.3–1.6 fold in the peas stand compared to the weed number in peas-cereals stands. In barley, wheat, oat and triticale stands the number of weeds was significantly lower than that for peas. Cereals and their mixtures with peas had the best suppressing ability compared to peas investigated. The dry mass of weeds in the peas stand was essentially higher than in the other stands of crops. The effect of pea mixtures with cereals crops on weed mass was similar as compared to that of pure cereals crops.

Keys words: mixing cropping, peas, spring cereals, weeds

INTRODUCTION

Weed management is a key issue in organic farming systems (Bond & Grundy, 2001). Weed biodiversity is widely reported to be higher in organic systems than in conventional (Boguzas et al., 2004; Roschewitz et al., 2005), however, there is some debate about whether or not weed densities are greater. Ngouajio & McGiffen (2002) argue that weed populations are not necessarily higher in organic production systems than in conventional ones due to the use of green manure crops and cover crops which reduce weed severity. Leeson et al. (2000), however, found that organic farms had a higher number of weeds after post-emergent weed control than conventional farms.

Weed control in organic cropping should primarily be tackled by altering the competitive balance between the crop and the weeds through such measures as correct choice of rotation, choice of crop species and variety, appropriate sowing arrangements, stale seedbeds, undersowing and other prophylactic weed management measures (Younie & Litterick, 2002). Individual cereal species vary in their competitiveness against weeds. Oats and triticale are more competitive than barley, and modern wheat varieties are poor competitors (Davies & Welsh, 2002). Field pea is poorly competitive against weeds compared with other crops, because they are grown at a low plant density, and seedling vigour can be poor (Mcdonald, 2003).

Mixed culture is one effective method in sustainable crop production. Planting more than one crop resulted in better use of resources, in comparison with monoculture

(Sobkowicz, 2006). Intercropping systems have many advantages: better use of resources for growth, control of weeds, pests and diseases and increase in stability of yield in different environmental conditions compared with sole cropping (Nargis Akter et al., 2004). Weed suppression has been found to be greater in intercrops compared with sole crops, indicating synergism among crops within intercrops (Liebman & Dyck, 1993; Bulson et al., 1997; Szumigalski, 2005; Deveikyte et al., 2008). Diversity of weeds was decreased in mixed stands, in comparison with monoculture (Gharineh & Moradi Telavat, 2009). Some researchers report advantages of various intercropping managements such as pea-wheat (Szumigalski, 2005), pea-barley (Hauggaard-Nielsen et al., 2006), pea-oats (Rauber et al., 2000).

The objective of the study was to determine the effect of intercropping field pea with barley, wheat, oat and triticale on weeds compared with pure crops.

MATERIALS AND METHODS

The experiment was conducted in field conditions in Dotnuva, centre of Lithuania (55˚ 24´N) on a loamy *Endocalcari-Epihypogleyic Cambisol* from 2007 to 2008. The main agrochemical parameters of the arable soil layer: pH - 7.5, humus content - 2.3%, available P - 74–79 mg kg^{-1} and K - 135–140 mg kg^{-1}. Spring barley (*Hordeum vulgare* L.), spring wheat (*Triticum aestivum* L.), spring oat (*Avena sativa* L.), spring triticale (*Triticale hexaploide* Lart.) and field pea (*Pisum sativum* L.) were sown as pure crops and in a dual intercrops with field pea and were grown for grain.

The experiment was designed as a randomized complete block with three replicates. Plot size was 30 m^2. The intercrop design was based on the proportional replacement principle, with mixed pea grain and cereals grain at the same depth in the same rows at relative frequencies of 50:50. Crops were cultivated according to organic management practices.

Weeds were assessed twice: at stem elongation growth stage (BBCH 35–36) and at development of grain-filling growth stage (BBCH 73). Weed mass and botanical composition was determined in 0.25 m^2 at 4 settled places of each treatment. Weed number and mass data were transformed to $\sqrt{x+1}$.

Compared with the 81-year mean (1927–2008) annual growing season rainfall, precipitation levels were different from the norm. The year 2007 was wet, with 131% precipitation in the growing season (April–July). The 2008 year was dry, characterized by an extremely dry spring (April–May) with 58% rainfall compared with the 81-year mean. May was very dry – precipitation 25% of the norm. This resulted in poor crop and weed establishment and growth.

RESULTS AND DISCUSSION

Results revealed that annuals dominated in the weed flora composition (7–18 species), while perennials were more recessive (2–8 weed species). In stem elongation growth stage (BBCH 35–36) 15–25 species of weeds were registered, while only a few of them were prevailing. *Chenopodium album* L., *Fallopia convolvulus* (L.) Löve and *Lamium purpureum* L. dominated in every year of the investigation (Table 1). The high number of *Chenopodium album* emerged in both years.

Table 1. Species composition of weeds (%) at BBCH 35–36.

Weeds	2007	2008
Annual dicotyledonous weeds		
Chenopodium album	22.6	61.7
Thlaspi arvense	2.6	0.0
Tripleurospermum perforatum	1.0	0.0
Viola arvensis	3.7	0.0
Fallopia convolvulus	1.6	1.5
Polygonum aviculare	0.9	0.0
Lamium purpureum	8.3	2.3
Chaenorhinum minus	4.6	0.0
Euphorbia helioscopia	0.0	2.0
Polygonum persicaria	0.0	1.1
Veronica arvensis	0.0	1.9
Stellaria media	0.0	7.2
Perennial dicotyledonous weeds		
Galega orientalis	5.6	0.0
Taraxacum officinale	3.0	0.0
Sonchus arvensis	0.0	2.5
Cirsium arvense	0.0	5.9
Other	46.0	13.9

Table 2. Number of weeds per m^2 in spring wheat and legumes pure and mixed stands at BBCH 35–36.

Treatment	Annual		Perennial		Total	
	2007	2008	2007	2008	2007	2008
Peas (control)	60.7	82.3	7.7	15.0	68.4	97.3
Spring wheat	96.3	63.7*	7.3	6.3	103.6	70.0**
Spring barley	97.7	84.3	10.3	5.3	108.0	89.7
Spring oat	111.7	82.0	6.0	6.7	117.7	88.7
Spring triticale	73.3	79.7	12.0	12.3	85.3	92.0
Peas + spring wheat	71.3	81.0	11.0	5.7	82.3	86.7
Peas + spring barley	106.3	67.0	8.0	13.7	114.3	80.1*
Peas + spring oat	82.7	74.3	9.7	14.0	92.4	88.3
Peas + spring triticale	77.7	71.7	6.7	9.0	84.4	80.7*

* differences are statistically significant as compared to the control at $P = 0.05$,
** - at $P = 0.01$.

In 2007, the five most prominent weeds in spring cereal crops and peas in pure and mixed stands were *Chenopodium album, Lamium purpureum, Viola arvensis* Murray, *Chaenorhinum minus* (L.) Lange. and *Galega orientalis* Lam. In 2008, *Chenopodium album, Stellaria media* (L.) Vill. and *Cirsium arvense* (L.) Scop. were the most abundant weeds in the crop stands. *Chenopodium album* consisted of about 62% of total weed number. Weed distribution in the experiment ranged from 68.4 to 117.7 plants m^{-2} while annual dicotyledonous weeds (83.6–94.9 %) predominated (Table 2). The number of weeds varied between years. A lower total number was determined in 2008, i.e. 70.0–97.3 plants per m^2. The number of annual weeds spread unevenly between treatments. The differences in weed number between treatments were not significant, except in the spring wheat stand in 2008.

Table 3. Number of weeds per m^2 in spring wheat and legumes pure and mixed stands at BBCH 73.

Treatment	Annual		Perennial		Total	
	2007	2008	2007	2008	2007	2008
Peas (control)	43.3	90.3	6.0	18.3	49.3	108.7
Spring wheat	14.7	72.7	9.0	4.7	23.7	77.3**
Spring barley	11.7	82.3	10.0	5.7	21.7	88.0
Spring oat	15.0	65.0*	8.7	5.7	23.7	70.7**
Spring triticale	29.7	73.3	7.3	13.3	37.0	86.7*
Peas + spring wheat	21.3	81.7	8.7	4.7	30.0	86.3*
Peas + spring barley	18.0	76.7	8.3	13.7	26.3	90.3
Peas + spring oat	13.3	63.7*	7.3	15.3	20.6	79.0*
Peas + spring triticale	29.0	77.7	5.7	11.3	34.7	89.0

* differences are statistically significant as compared to the control at $P = 0.05$, ** - at $P = 0.01$*.

The number of perennials also varied irregularly. The effect of the crop and their mixture on perennials was not revealed. Differences of total weeds number were investigated in 2008. Pea growth intercropped with spring barley and spring triticale instead of pure crop had greater competitive ability on weeds. This reduction was significant as compared with the peas stand. The spring wheat stand suppressed weeds more effectively than other cereals.

In the stem elongation growth stage the suppressing ability of peas – cereals intercrop stand was not revealed, except for peas – spring barley and peas – spring triticale intercrops stand in 2008. Weed number at development of the grain filling growth stage (BBCH 73) is illustrated in Table 3. It should be noticed that in agrocenosis consisting of peas and their mixtures with cereals the number of weeds reduced from stem elongation to the grain-filling stage of crop development. This was the case in 2007, which was favorable for crop growing. This shows that some weeds died as compared to the first weed-counting time. The similar changes in weed population were registered also by other scientists (Pilipavičius, 2005). The results of this experiment showed that there were more estimated differences among crop treatments at this growth stage than in stem elongation stage (BBCH 35–36). The effect of pea pure stand on the number of annual weeds was lower compared to that of peas-cereals mixed. However, differences were not essential, except in spring oat pure stand and spring oat mixture with peas in 2008. The number of perennial weeds among treatments varied irregularly. Differences were not statistically different. The number ranged from 4.7 to 18.3 plants m^{-2}. In 2007 the differences in total number of weeds were not significant among all crop treatments. In 2008 the mixed culture of peas-spring wheat and peas-spring oat, and spring barley, spring oat and spring triticale pure stands had a significant weed suppressive effect on the total number of weeds as compared with peas stand. Results show the highest number of weeds in pure peas crops. Similar results have been reported previously (Hauggard-Nielsen et al., 2001, 2006). However, the number of weeds was higher by average 1.1 fold in cereals pure stand as compared to peas–cereals intercrops. Results showed that intercrops can be an effective implement for weed control, agreeing with the results found in literature (Hauggaard-Nielsen et al., 2001; Saucke & Ackermann, 2005; Gharineh & Moradi Telavat, 2009).

Table 4. Air-dry mass of weeds (g per m^2) in spring wheat and legumes pure and mixed stands at BBCH 73.

Treatment	Annual		Perennial		Total	
	2007	2008	2007	2008	2007	2008
Peas (control)	29.0	69.8	7.3	29.5	36.3	99.3
Spring wheat	1.2**	16.1**	6.4	2.5**	7.6	18.6**
Spring barley	1.4**	9.5**	6.3	5.5*	7.7	15.0**
Spring oat	1.3**	6.7**	10.6	6.0*	11.9	12.7**
Spring triticale	3.9**	9.3**	4.9	14.7	8.8	24.1**
Peas + spring wheat	5.4**	28.6**	9.3	6.8*	14.7	35.4**
Peas + spring barley	3.4**	19.1**	6.2	9.0*	9.6	28.2**
Peas + spring oat	2.2**	11.9**	5.7	6.9*	7.9	18.8**
Peas + spring triticale	8.1	14.0**	6.4	13.3	14.5	27.3**

* differences are statistically significant as compared to the control at $P = 0.05$, ** - at $P = 0.01$.

For evaluation of weed infestation it is important to know not only the number of weeds, but their mass as well. Cereals were particularly more effective at suppressing annual weed mass than peas (Table 4). For both years the spring wheat, spring barley, spring oat and spring triticale pure stand and their mixture with peas had significant weed suppressive effect on the mass of annual weeds. Crop treatment had a significant effect on perennial weed mass in 2008 only. The mass of perennial weeds in the spring triticale stand was lower than in other stands of cereal crops in 2007, but in 2008 it was higher, except in the pure peas stand. The mass of perennial weeds in intercrop peas-spring triticale also was higher than in other intercrops in 2008. The total weed mass differed by year. In 2007 significant differences were not revealed, but could be seen in 2008. The weed mass of intercrop treatments did not differ from the pure cereal crops stand. The total mass of weeds in peas was higher by 2.8–7.8 folds as compared to the other crop treatments. Poggio (2005) found that intercrops and barley monocultures generally produced similar effects on the companion weed communities, whereas pea effects were less suppressive.

CONCLUSIONS

1. Annuals dominated in the weed flora composition (7–18 species), while perennials were more recessive (2–8 weed species). In stem elongation growth stage (BBCH 35–36) 15–25 species of weeds were registered, while only a few prevailed: *Chenopodium album*, *Fallopia convolvulus* and *Lamium purpureum*.

2. Peas – cereals intercrop stand suppressing ability was revealed only at the development of the grain-filling growth stage (BBCH 73) and during favorable crop growing conditions.

3. Peas had the lowest suppressing ability on weeds, yielding 2.8-7.8-fold higher total air-dry mass of weeds as compared to all other stands of cereal crops.

4. Weed infestation in the peas-–cereals mixtures stand was significantly lower than that in the pure pea stands.

5. The effect of pea mixtures with cereals crops on mass of weeds was similar to that of the pure cereals crop.

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