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Mixed cropping systems for biological control of weeds and pests in organic oilseed crops

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Summary

Agricultural advantages of mixed cropping are gained by biological effects like light competition, offering weed-suppressing capacities or by diversification of plant covers to break development cycles of pests. In a two-year project on mixed cropping with organic oilseed crops these effects were measured. It was found that weeds can be efficiently suppressed in organic linseed (*Linum usitatissivum*) in crop combinations with wheat (*Triticum aestivum*) or false flax (*Camelina sativa*). But linseed development was strictly limited. Also in organic pea production (*Pisum sativum*) the introduction of mixtures with the oil crop false flax led to a significant decrease of weed population. Either culture showed a balanced plant development. In winter rape (*Brassica napus*) hints were found that infestation by insect pests can be directly reduced in mixtures with cereals or legumes and that parasitoids of insect pests are supported.

Key words: mixed crops, weed suppression, insect pests, beneficial parasitoids

Introduction

Mixed cropping systems in organic farming offer a yield buffer capacity by diverse growing demands and different periods of root, leave and seed development of the plant varieties. In the last years mixed cropping is seen as a chance to secure production of organic oilseed crops and to gain a fuel autarky for organic farms (Paulsen & Rahmann, 2004). In mixed cropping light competition can offer weed-suppressing capacities (Szumigalki & van Acker, 2005). The increase in vegetational complexity can interfere with host-plant location of crop pests (Horn, 2000). Furthermore an increase of natural enemies of pests is hypothesized (Andow, 1991).

Materials and Methods

The field trials were conducted at two organic farms in Northern Germany (Trenthorst and Wilmersdorf) in 2004 and 2005. Plots (size: 30 m^2) with sole cropped oilseeds were compared to mixed cropping variants. Annual rainfall and mean temperatures in 2004 and 2005 were 660 and 570 mm and 7.7 and 7.6 °C in Trenthorst respectively and 560 and 490 mm and 7.5 and 7.3 °C in Wilmersdorf. Soils (Luvisols) with clay contents between 15 and 20 % in Trenthorst and up to 15 % in Wilmersdorf were sufficiently supplied with plant nutrients. Preceding crop was clover grass. Combinations of linseed with false flax or spring wheat and of peas with false flax are highlighted to show effects of mixed cropping on weed establishment. In seeding rates additive and competitive mixtures were chosen, according to the proper establishment of the single cultures, so that mixed and sole cropping systems grew with adopted but partly different plant densities. All treatments were drilled with a row distance of 12.5 cm, mixed crops in alternating rows. Plant densities of weeds and crops were determined by visual assessment of the percentage of soil covering at the end of the shoot development. Main weeds in Trenthorst were *Galium aparine, Capsella bursa-pastoris* and *Matricaria recutita* in 2004 and *Stellaria media* and *Matricaria recrutita* in 2005, *Trifolium repens* formed a relevant intercrop in that year. In Wilmersdorf *Matricaria recutita*, *Agropyron repens* and *Stellaria media* (2004), and *Chenopodium album, Matricaria recutita* and *Agropyron repens* (2005) were the major weeds. Effects of mixed cropping systems with winter rape on the abundance and damage potential of insect pests were determined in another part of the project. Insects infesting stems (*Psylliodes chrysocephala, Ceuthorynchus pallidactylus, Ceutorhynchus napi*), buds (*Meligethes aeneus*) and pods (*Dasineura brassicae, Ceutorhynchus assimilis*) were monitored. Additionally the effects of the cropping systems on the level of larval parasitism of *M. aeneus* (parasitoids: *Tersilochus heterocerus, Phradis interstitialis*) and *C. pallidactylus* (parasite: *Tersilochus obscurator*) were determined.

Results

Weed suppression

In mixed cropping systems with linseed and false flax the soil covering was efficiently increased compared to the sole cropping of linseed and was comparable to sole cropped false flax (Table 1). False flax was dominating the mixture (Figure 1) in both years. Weed covering was decreased between 70 and 80 % in Wilmersdorf in 2004 and 2005 respectively. Even at the site of Trenthorst; that showed relatively moderate weed pressure, reduction of weed covering ranged between 70 % in 2004 and 20 % in 2005. In the mixture of peas with false flax equal effects were visible. Especially in 2004 when pea development in Wilmersdorf was inadequate false flax efficiently reduced weed-covering by 90 % to tolerable levels comparable to the weed-covering in false flax determined in pure stand (10.7 %, table 1).

Table 1. *Soil covering [%] of crops and weeds in mixed and sole cropping systems with oil crops at the end of the shooting stage at two sites in 2004 and 2005. Results of ANOVA comparing values of the mixed cropping systems (in brackets) to the sole cropping system (before bracket). L=Linseed, FF=False flax, SW=Spring wheat, P=peas*

Trent. 2004 2004	SW(SW/L) Crop	Weed	L(SW/L) Crop	Weed	L(L/FF) Crop	Weed	FF(L/FF) Crop	Weed	P(P/FF) Crop	Weed	FF(P/FF) Crop	Weed
Mean Sole	81.3	1.5	85.0	8.1	85.0	8.1	97.5	5.8	85.0	12.5	97.5	5.8
Mean Mixed	70.0	2.7	70.0	2.7	103.8	4.5	103.8	4.5	97.5	4.0	97.5	4.0
F-Test	*	ns	**	*	**	ns	ns	ns	*	ns	ns	**
$LSD_{5\%}$	7.6	-	6.5	3.8	7.6	-	-	-	10.3	-	-	0.8
Wilm. 2004												
Mean Sole	70.0	4.3	43.8	34.3	43.8	34.3	85.0	8.5	13.8	102.7	85.0	8.5
Mean Mixed	61.3	11.0	61.3	11.0	85.5	8.8	85.5	8.8	98.8	10.7	98.8	10.7
F-Test	ns	*	ns	ns	*	ns	ns	ns	***	*	*	ns
$LSD_{5\%}$	-	6.6	-	-	30.3	-	-	-	16.9	73.4	13.2	-
Trent. 2005												
Mean Sole	85.0	3.3	71.3	7.0	71.3	7.0	90.0	8.5	91.3	3.8	90.0	8.5
Mean Mixed	60.0	5.0	60.0	5.0	87.5	6.5	87.5	6.5	92.5	3.0	92.5	3.0
F-Test	No var.	ns	*	*	***	ns	ns	ns	ns	ns	ns	*
$LSD_{5\%}$		-	7.6	1.3	4	-	8	-	-	-	-	4.6
Wilm. 2005												
Mean Sole	82.5	6.8	13.3	54.3	13.3	54.3	70.0	27.5	65.0	37.0	70.0	27.5
Mean Mixed	52.0	10.8	52.0	10.8	60.3	18.3	60.3	18.3	77.5	26.8	77.5	26.8
F-Test	***	*	***	**	**	*	ns	ns	ns	ns	ns	ns
$LSD_{5\%}$	4.2	2.3	7.8	19.3	19.7	22.1	-	-	-	-	-	-

with: *** = $0 \le P < 0.001$, ** = $0.001 \le P < 0.01$, * = $0.01 \le P < 0.05$, ns = $P \ge 0.05$

In Trenthorst 2004 and at both sites in 2005 pea development was clearly reduced by the false flax (figure 1). Weed suppression was forced in the pea/false-flax mixtures compared to the false flax in sole cropping in Trenthorst in both years. In Wilmersdorf 2005 the weed reduction in pea/false flax mixtures could not be statistically verified. It reached the level of the weed-covering in sole cropped false flax. The mixed cropping system of summer wheat with linseed showed a different balance than the mixtures described before. Compared to sole cropped wheat, mixed cropping of wheat with linseed had lower crop densities and higher weed-covering. This effect can be explained by seeding the components in alternating rows. This makes the equal crop cover of the two crops with an upright growing habit relatively more variable. Seen from the linseed as target culture for weed reduction, intolerable weed-covering rates of 34 and 54 % in pure linseed in Wilmersdorf in 2004 and 2005 could be reduced significantly in a mixture with wheat to an acceptable level of 10 % by increasing the soil covering of crops (table 1). But wheat was dominating the mixture and affects the development of linseed negatively. Due to the row bound development of the canopy, effects of the seeding in alternating rows and of plant competition could not be distinguished. On the site of Trenthorst, with a favourable linseed development, mixtures with spring wheat led to lower plant covering values when compared to sole cropped linseed. But significant reductions in weed covering in the mixed cropping system at this site in both years compared to sole cropped linseed hint to competitive strength of the mixture in earlier growth stages.

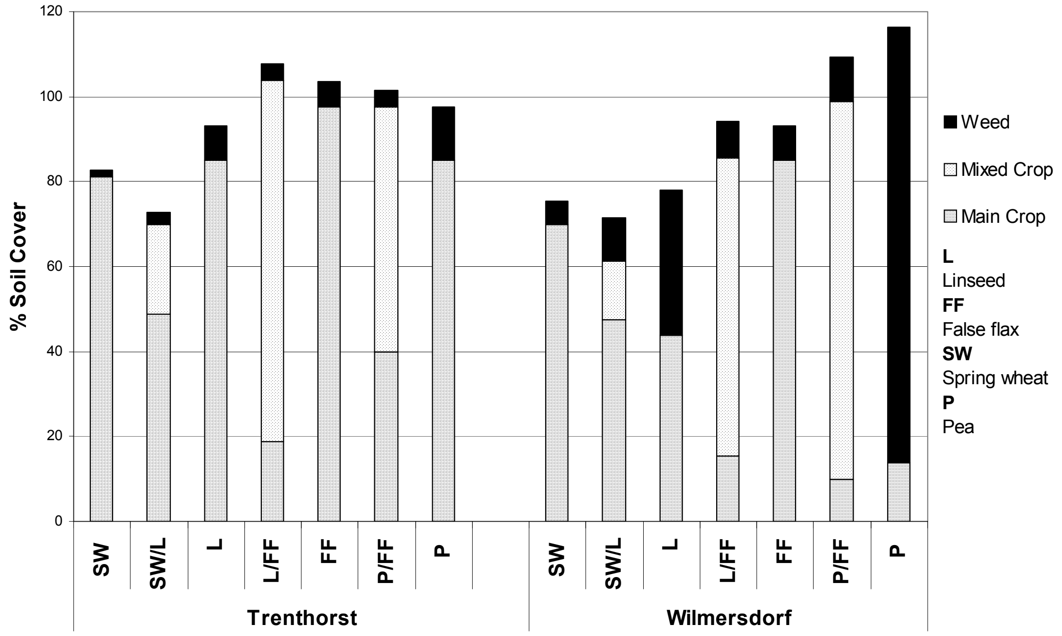

Figure 1. *Soil covering [%] of crops and weeds in mixed and sole cropping systems with oil crops at the end of the shooting stage at two sites in 2004. Main crop in each bar is the first crop mentioned at the abscissa.*

Insect pests and beneficial parasites

For the stem-mining insect pests of winter rape only *the abundance* of *C. pallidactylus* was significantly influenced by the cropping system (Table 2). At site of Trenthorst in 2004, in the fully developed mixed cultures with winter barley or winter peas the number of larvae in oilseed rape plants was reduced as compared to sole winter rape. However, in the mixture of spring peas with winter rape the establishment of spring peas almost totally failed in that year and the crop consisted mainly of winter rape in low seed density. Another significant effect of mixed cropping was found in Wilmersdorf 2005. Larvae of *M. aeneus* showed a higher percentage of parasitism by *T. herterocerus* and *P. interstitialis* when sampled from oilseed rape cropped with winter barley, winter peas or winter rye compared to larvae from sole cropped rape (Table 2). In

2005, losses of buds caused by *M. aeneus* and the level of pod infestation by *D. brassicae* or *C. assimilis* or the number of stem-mining insects were not influenced by the treatments.

Table 2. *Larval abundance and parasitism of insect pests and their damage to winter rape (WR) grown in sole and mixed cropping. WB=Winter barley, WW=Winter wheat, WP=Winter peas, SP=Spring peas, WRye=Winter rye, (mean± SD, n=4 per treatment)*

	Trenthorst 2004				*Wilmersdorf 2005*		*Mean of both sites 2005*	
Winter Rapeseed cropped with	*Psylloides*	*C. napi*	*C. pallidactylus*	Larval parasitism	*M.aeneus* larvae	Larval parasitism	M. *aeneus* Bud-losses by	*D. brassicae* *C. assimilis* Pods infested by
	larvae/plant	larvae/plant	larvae/plant	%	no/10 stems	%	%	%
WR sole	0.4 ± 0.3	3.2 ± 1.1	6.7 ± 2.3	15.3 ± 9.4	47.5 ± 23.3	5.4 ± 4.6	42.7 ± 19.0	14.6 ±12.2
WB (WW [a])	0.5 ± 0.1	3.2 ± 2.1	3.5 ±1.0	9.3 ± 13.1	37.3 ± 13.5	12.0 ± 4.5	40.0 ± 17.1	21.2 ± 13.7
WP	1.0 ± 1.1	3.6 ± 1.7	3.4 ± 0.6	9.7 ± 7.0	40.8 ± 13.5	17.3 ± 5.2	41.6 ± 16.7	14.8 ± 17.0
SP (WRye[b])	0.6 ± 0.4	4.6 ± 2.3	7.0 ± 2.0	16.4 ± 9.6	38.3 ± 15.8	11.0 ± 4.3	45.2 ± 20.3	17.8 ± 11.6
F-Test	ns	ns	**	ns	ns	*	ns	ns
$LSD_{10\%}$	-	-	1,9	-	-	6	-	-

[a]WW at site of Trenthorst 2005, [b]WRye at both sites 2005, with: *** = 0 ≤ P < 0.001, ** = 0.001 ≤ P < 0.01, * = 0.01 ≤ P < 0.05, ns = p ≥ 0.05

Discussion

Mixed cropping systems were an efficient measure to suppress weeds in linseed. But linseed development was influenced negatively in combinations with false flax or summer wheat. Yield balances of organic mixed cropping systems with oil crops will determine the profitability and their practical relevance. Share of component yields can be influenced by varying seeding techniques in row distances and seed densities and have to be further adopted. Weed suppression capacities of the oil crop false flax in combination with peas was equally effective and offered more balanced plant development of both components. Seed yield reductions of the peas were proofed to be of minor importance and additional oilseed yields are reported in this cropping system (Paulsen & Rahmann, 2004). Monitoring of insect pests in organic winter rape grown in mixed cropping with cereals or legumes provided first interesting hints that diversification of crop covers and breaking up monocultures have a potential to reduce pest infestation directly or by enhancing their biological control by parasitoids. However, further studies on the effect of mixed cropping of oilseed rape with other crops on pest insects and their parasitoids are needed.

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