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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 from biological effects like light competition offering weed-suppressing capacities, or by diversification of plant covers to break development cycles of pests. These effects were measured in a two-year project on mixed cropping with organic oilseed crops. It was found that weeds can be efficiently suppressed in organic linseed (*Linum usitatissivum*) grown in combination with wheat (*Triticum aestivum*) or false flax (*Camelina sativa*). Linseed growth was, however, impaired. In organic pea production (*Pisum sativum*) also, growing the crop as a mixture with false flax led to a significant decrease of weed population. Either culture showed a balanced plant development. In winter rape (*Brassica napus*) there were suggestions 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 buffering capacity by diverse growing demands and different periods of root, leaf and seed development of the plant varieties. In recent years, mixed cropping has been seen as a chance to secure production of organic oilseed crops and to gain fuel self-sufficiency for organic farms (Paulsen & Rahmann, 2004). In mixed cropping competition for light can offer weed-suppressing capacities (Szumigalki & van Acker, 2005). The increase in vegetational complexity can interfere with the host-plant location of crop pests (Horn, 2000). Furthermore an increase of natural enemies of pests has been hypothesised (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 with 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. The preceding crop was a clover-grass mixture. Combinations of linseed with false flax or spring wheat and of peas with false flax were tested to show the effects of mixed cropping on weed establishment. Seed rates were chosen according to the proper establishment of single cultures, so that mixed and sole cropping systems grew with different plant densities. All treatments were drilled with a row distance of 12.5 cm, with mixed crops in alternating rows. Plant densities of weeds and crops were determined by visual assessment of the percentage of soil covered at the end of shoot development. The main weeds in Trenthorst were *Galium aparine*, *Capsella bursa-pastoris* and *Matricaria recutita* in 2004 and *Stellaria media* and *Matricaria recutita* 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 cover was efficiently increased compared to the sole cropping of linseed and was comparable to sole cropped false flax (Table 1). False flax dominated the mixture (Fig. 1) in both years. Weed cover decreased by between 70 and 80% in Wilmersdorf in 2004 and 2005 respectively. Even at Trenthorst, which showed only moderate weed pressure, the reduction of weed cover ranged from 70% in 2004 to 20% in 2005. In the mixture of peas with false flax similar effects were visible. In 2004, when pea growth at Wilmersdorf was inadequate, false flax efficiently reduced weed-cover by 90% to tolerable levels comparable to the weed-covering in false flax determined in pure stand (10.7%, Table 1).

In Trenthorst in 2004 and at both sites in 2005, pea growth was clearly reduced by the false flax (Fig. 1). Weed suppression was forced in the pea/false-flax mixtures compared to the false flax in sole cropping in Trenthorst in both years. However, in Wilmersdorf in 2005, the weed reduction in pea/false flax mixtures was not statistically significant. 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 from the mixtures described before. Compared to sole cropped wheat, mixed cropping of wheat with linseed had lower crop densities and a higher weed-cover. This effect can be explained by the components being seeded in alternate rows. This makes the equal crop cover of the two crops with an upright growing habit relatively more variable. Taking linseed as the target culture for weed reduction, intolerable weed-cover of 34% and 54% in pure linseed in Wilmersdorf in 2004 and 2005 was reduced significantly in a mixture with wheat to an acceptable level of 10% by increasing the crop cover (Table 1).

However, wheat dominated the mixture and reduced the growth of linseed. Due to the row-bound development of the canopy, effects of seeding in alternating rows could not be distinguished from the direct effects of plant competition. At Trenthorst, where linseed growth was favourable, mixtures with spring wheat led to a lower plant cover than in sole cropped linseed. Significant

Table 1. *Soil cover [%] 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	**SW(SW/L)**		**L(SW/L)**		**L(L/FF)**		**FF(L/FF)**		**P(P/FF)**		**FF(P/FF)**	
2004	**Crop**	**Weed**	**Crop**	**Weed**	**Crop**	**Weed**	**Crop**	**Weed**	**Crop**	**Weed**	**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 = $P \ge 0.05$

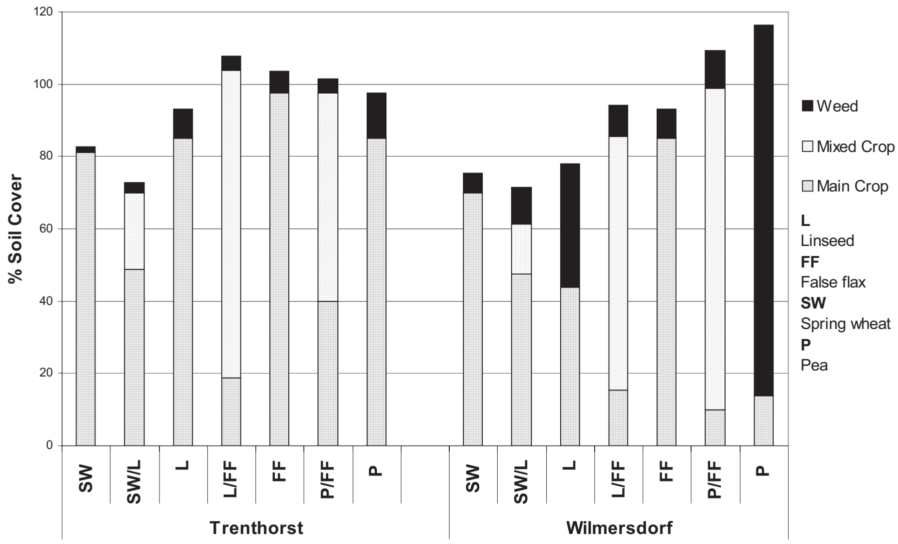

Fig. 1. Soil cover [%] of crops and weeds in mixed and sole cropping systems with oil crops at the end of the shooting stage at two sites in 2004. Main crop in each bar is the first crop mentioned at the abscissa.

reductions in weed cover in the mixed cropping system at this site in both years hint at a competitive advantage of the mixture in earlier growth stages.*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 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 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 at a low density. Another significant effect of mixed cropping was found in Wilmersdorf in 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*, the level of pod infestation by *D. brassicae* or *C. assimilis* and the

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* larvae/plant	*C. napi* larvae/plant	*C. pallidactylus* larvae/plant	Larval parasitism %	*M.aeneus* larvae no/10 stems	Larval parasitism %	Bud-losses by M. *aeneus* %	*C. assimilis* Pods infested by *D. brassicae* %
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

number of stem-mining insects were not influenced by the treatments.

Discussion

Mixed cropping systems were an efficient way to suppress weeds in linseed. However, linseed growth was reduced 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. The share of component yields can be influenced by row distances and seed densities and have to be further researched. Weed suppression capacities of the oil crop false flax in combination with peas were equally effective and offered more balanced plant growth of both components. Seed yield reductions of the peas were shown to be of minor importance and additional oilseed yields have been reported in this cropping system (Paulsen & Rahmann, 2004). Monitoring of insect pests in organic winter rape grown in mixed cropping with cereals or legumes suggested 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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