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Institute of Plant Protection – NRI

CORE organic

PRODIVA - Crop diversification and weeds

Work package 2: Crop mixtures for weed suppression
Annual report 2016

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Summary

The aim of WP2 is to assess the weed suppressive ability of crop mixtures as a function of species and densities, using a functional approach. During 2016, field experiments and controlled experiments with mixtures of barley and pea were conducted in Sweden and Poland. The performance of crop mixtures was compared to the performance of pure crops with regard to their ability to suppress weeds. In the fields, natural weed populations were used while the controlled experiments employed *Elytrigia repens* or *Sinapis alba* as a model weed. The purpose was to quantify weed suppressive ability of the crops, the impact of weeds on crop yield, and to identify crop traits responsible for the effects on weeds and crop yield.

Preliminary results from the controlled experiment in Sweden showed that the presence of a crop (sole crop or intercrop) significantly diminished the growth of *E. repens.* The ability to compete (weed suppressive ability) was lower in peas, compared to barley and the intercrop. No significant differences were found in the ability to withstand competition (weed tolerance) between sole cropped pea, sole cropped barley, and the intercrop. In the field experiment, the overall weed pressure was rather high (> 500 g DM plot^{-1}). No significant differences in total dry matter were found for spring barley, sown in different proportions in pea/spring barley mixtures. Total dry matter of peas was related to pea seeding density.

Preliminary results from the field experiment in Poland showed that crops significantly suppressed weeds compared with the treatment containing only weeds. In the crop combination containing sole peas and 70% peas + 30% spring barley, the crop was not able to suppress the weeds as efficient as in treatments with a higher proportion of spring barley. No significant differences in seed yield were found between the treatments. In the glass house experiment with *E. repens*, the rhizome dry weight and rhizome length were significantly lower in treatments with both crop and weeds as compared with pure weeds.

Background

Before performing experiments, the literature was reviewed to identify traits of importance for weed control by means of crop mixtures, and to obtain an overview of methods to quantify weed suppressive ability of crop components in a mixture. Liebman and Dyck (1993) found that, out of 24 intercropping studies where all component crops were considered main crops, in 50 % of the cases the weed biomass reduction was greater in the intercrop (IC) than in sole crops (SC) of all component species. In 42 % the intercrop was intermediate to the component crops regarding weed suppression and in 8 % the intercrop was weaker than the component crops in sole cropping. According to Larsson (1990) mixing species can be an effective way to prevent nutrient leakage and weed growth since the component species have different ranges of uptake and may make a good combination for competition against weeds.

It has been shown by a number of studies that pea suppresses weeds to a lesser extent than barley and their intercrop (e.g. Corre-Hellou et al., 2011; Mohler and Liebman, 1987; Poggio, 2005). This is an overall conclusion from experiments done mainly with different plant densities and nitrogen applications as treatments. Due to a more efficient resource capture the intercrops suppressed weeds to a greater extent than the different sole crops of pea and barley. In addition there was less plant disease to be found in the intercrops. A further benefit is that the cereal/legume mixtures grown for seed produced more protein compared to the pure stands (Buraczyńska & Ceglarek, 2009). Mohler and Liebman (1987) observed in their work with barley, pea, annual weeds and *E. repens*, that weed density decreased with increasing crop density and that the barley-pea intercrop did not show any advantage regarding weed suppression compared to sole cropped barley. Biomass production of the stands was barley > intercrop > pea for all treatments and the weed biomass showed the inverted results, i.e. weed only > pea > intercrop > barley. This is in line with the results of Corre- Hellou et al. (2011) and Poggio (2005). Corre-Hellou et al. (2011) showed that pea SC and intercrops had higher LAIs than barley SC. In 20% of the cases, an IC produced a higher LAI than a pea SC. Barley LAI was coupled to nitrogen: lower LAI at lower soil N availability. An increase in LAI of a pea SC led to increased weed suppression. Regardless of LAI, pea SC plots contained more weed biomass than ICs and barley SC. The decrease in weed dry matter was similar for barley SC and ICs independently of their LAI (Corre-Hellou et al., 2011). Liebman and Robichaux (1990) showed though that shading by the crops (pea and barley) became less important as a competitive parameter against weeds at high fertilization and that the competitive advantage of their pea-barley-intercrop was greater at the low fertilization rate. The canopy's importance for weed suppression was further studied by Liebman (1989) who showed that the pea leaves' ability to shade does become important at well-fertilized conditions.

Activities in Sweden 2016

Experiments

During the growing season of 2016, a controlled box experiment was performed outdoor to assess the weed-suppressive ability of a spring barley/pea mixture and its components in monocultures, with a focus on the leaf area index and light extinction. A substitutive completely randomized experimental design with a fixed crop/crop seeding density was used with seven treatments and six replicates. The rhizomatous perennial *Elytrigia repens* (L.) Desv. ex Nevski (Couch grass) was established as a weed, including a number of annual species. Various parameters were measured during the experimental period to assess the weed suppressive ability of both crop mixtures and monoculture stands. Also the ability to withstand competition or weed tolerance was quantified. And finally synergistic effects of crop mixtures on weed biomass were scrutinized.

Also, a field experiment with different proportions of spring barley plus pea mixtures was established (six treatments in four replicates) (see Table 2). The weed flora in the field consisted of mainly of *Cirsium arvense* (L.) Scop. (Canada thistle) and *E. repens*. To avoid damages by birds in the field experiment, microplots (1.2 x 0.8 m) were established which enabled protection from birds early in the season. The experiment was sown in the end of May and harvested in the end of August.

Preliminary results

Preliminary results from the controlled experiment in Sweden showed that the presence of a crop (sole crop or intercrop) significantly diminished the growth of *E. repens* (Table 1). The ability to compete (weed suppressive ability) was lower in peas, compared to spring barley and the intercrop. No significant differences were found in the ability to withstand competition (weed tolerance) between sole cropped pea, sole cropped spring barley, and the intercrop.

Table 1. Box experiment in Sweden 2016. Total dry matter weight (DM) (g box^{-1}) and rhizome DM weight (g box^{-1}) of Elytrigia repens in the seven different treatments in box experiment in Sweden 2016. Mean and confidence limits. Box size = 0.80 m^2.

Treatments	**Total weight, *E. repens* (DM, g box^{-1})**	**Rhizome weight, *E. repens* (DM, g box^{-1})**
1. *Elytrigia repens*, pure stand	382, 352–411	86, 74–98
2. Spring barley	-	-
3. Peas	-	-
4. Spring barley + *E. repens*	29, 0–58	5, -7–17
5. Peas + + *E. repens*	38, 9–68	11, -2–23
6. Spring barley (50%) + peas (50%)	-	-
7. Spring barley (50%) + peas (50%) + *E. repens*	17, -12–46	3, -9–16

In the field experiment, the overall weed pressure was very high (> 500 g DM plot^{-1}). No significant differences in total dry matter were found between the treatments regarding spring barley and weeds. Total dry matter of peas was significantly higher in sole peas as compared to a crop mixture with 30% peas (Table 2).

Table 2. Field experiment in Sweden 2016. Total dry matter (DM) (g plot^{-1}) of weeds, spring barley and peas in the six different treatment in field experiment in Sweden 2016. Mean and confidence limits. Plot size = 0.96 m^2.

Treatment	Weeds total weight, (DM, g plot^{-1})	Spring barley total weight, (DM, g plot^{-1})	Peas total weight (DM, g plot^{-1})
1. Spring barley + weeds	517, 347–687	213, 47–379	-
2. Peas + weeds	697, 527–867	-	56, 41–71
3. Spring barley (70%) + peas (30%) + weeds	608, 438–779	282, 115–448	18, 4–33
4. Spring barley (50%) + peas (50%) + weeds	598, 428–768	157, -9–323	33, 18–48
5. Spring barley (30%) + peas (70%) + weeds	482, 312–652	215, 49-381	39, 24–54
6. Weeds, pure stand	670, 500–840	-	-

Activities in Poland 2016

Experiments
Similar to and in close collaboration with Sweden, a field experiment with different proportions of spring barley plus pea mixtures was established in 2016 in a field with a natural weed population (randomized block design with six treatments in four replicates, see treatments in Table 2). Canopy development of both pure stands and mixtures were measured: gNDVI (*Green Normalised Difference Vegetation Index*) using unmanned aircraft systems and LAI (*Leaf Area Index*) using a hand instrument as one of the most important parameters for canopyarchitecture. Destructive yields were performed on 9 June and 22 July at which date the experiment was harvested. Also number of ears/grain and pods/seeds (No/m2), and the quantity and quality of yield were assessed.

Two controlled experiments were also performed during 2016. One glass house experiment with *E. repens* as model weed and one growth chamber experiment with *Sinapis alba* L. as model weed. In both experiments, seven combinations of barley, peas and weeds were used. The following assessments were performed: dry mass of crops and weeds (*E. repens, S. alba*), couch grass rhizome weight and length per unit, number and weight of seeds per unit, number of ears/grain and pods/seeds (No/pot).

Preliminary results

In the field experiment, crops significantly suppressed weeds compared with the treatment containing weeds only (treatment 6) (Table 3 and 4). In crop combinations containing sole peas (treatment 2), 50% spring barley + 50% peas (50%) (treatment 4), and 70% peas + 30% spring barley (treatment 5), the crops were not able to suppress the weeds as efficient as in treatments 1 and 3 (Table 3 and 4). In contrast with the other treatments, weed biomass decreased over time in the crop mixtures containing 70% spring barley + 30% peas (treatment 3) and 50% spring barley + 50% peas (treatment 4). No significant differences in seed yield were found between the treatments (Figure 1). The reason was probably the dry weather conditions during the growing season.

Table 3. Field experiment in Poland 2016. Total dry matter (DM) (g m^{-2}) of weeds, spring barley and peas in full growing vegetation in the six different treatment in field experiment 09.06.2016 in Poland. Mean and confidence limits. Plot size = 15m^2.

Treatment	Weeds total weight, (DM; g m^{-2})	Spring barley total weight, (DM; g m^{-2})	Peas total weight (DM; g m^{-2})
1. Spring barley + weeds	46; -11–103	152; 105–199	-
2. Peas + weeds	88; 24–152	-	190; 126–254
3. Spring barley (70%) + peas (30%) + weeds	61; -10–132	88; 30–146	106; -3–215
4. Spring barley (50%) + peas (50%) + weeds	127; 47–207	80; 35–125	91; 23–159
5. Spring barley (30%) + peas (70%) + weeds	115; 5–225	74; 2–146	125; 67–183
6. Weeds, pure stand	219; -1–439	-	-

Table 4. Field experiment 2016 in Poland. Total dry matter (DM) (g m^{-2}) of weeds, spring barley and peas at the end of the growing vegetation in the six different treatment in field experiment 22.07.2016. Mean and confidence limits. Plot size = 15m^2.

Treatment	Weeds total weight, (DM; g m^{-2})	Spring barley total weight, (DM; g m^{-2})	Peas total weight (DM; g m^{-2})
1. Spring barley + weeds	86; 11–161	147; 113–181	-
2. Peas + weeds	194; -47–435	-	363; 88–638
3. Spring barley (70%) + peas (30%) + weeds	43; -7–93	182; 133–231	127; -25–279
4. Spring barley (50%) + peas (50%) + weeds	98; -17–213	142; 94–190	186; -84–456
5. Spring barley (30%) + peas (70%) + weeds	154; -132–440	123; 51–195	225; 47–403
6. Weeds, pure stand	407; 123–691	-	-

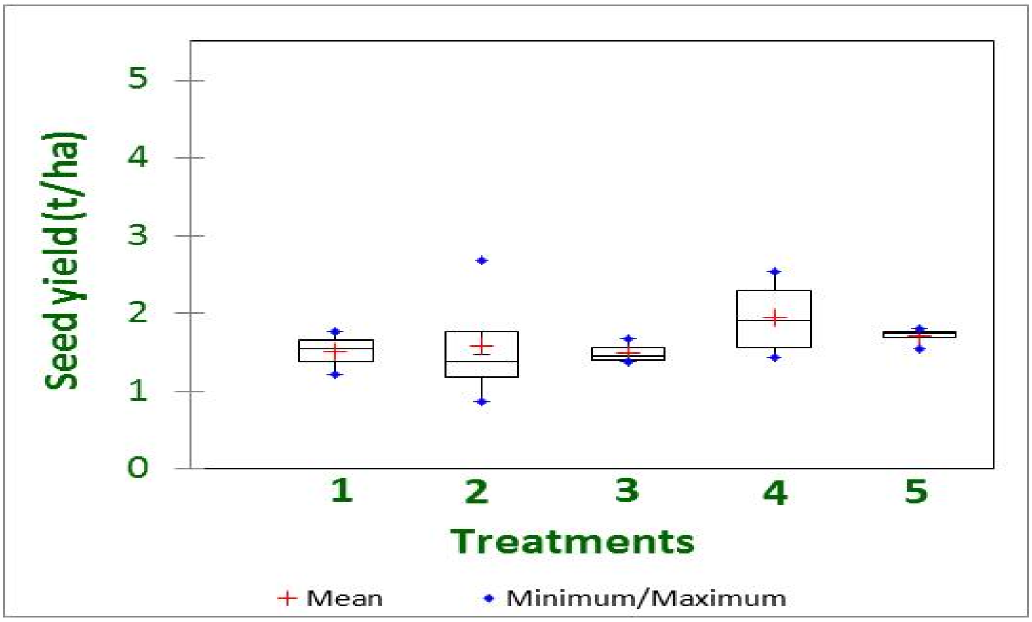

Figure 1. Field experiment 2016 in Poland. Seed yield (tons ha^{-1}) in the five different treatments with crops (1-5). 1: Spring barley, 2: Peas, 3: Spring barley (70%) + peas (30%), 4: Spring barley (50%) + peas (50%), 5: Spring barley (30%) + peas (70%). Box and whisker plot with: Means (+), median (–), minimum/maximum (◊), the 25th percentile, and the 75th percentile.

In the glass house experiment with *E. repens*, the rhizome dry weight and rhizome length were significantly lower in treatments with both crop and weeds (treatments 4,5, and 7) as compared with pure weeds (treatment 1) (Table 5).

Table 5. Glass house experiment in Poland 2016. Total dry matter weight (DM) (g pot^{-1}), rhizome DM weight (g pot^{-1}) and rhizome length (cm pot^{-1}) and weight (g pot^{-1}) of Elytrigia repens in the seven different treatments. Mean and confidence limits. Pot size = 24 cm x 24 cm (0.0576 m^2).

Treatments	**Total weight *E. repens* (DM, g pot^{-1})**	**Rhizome weight *E. repens* (DM, g pot^{-1})**	**Rhizome lenght *E. repens* (cm pot^{-1})**
1. *Elytrigia repens*, pure stand	6.71; -5.36–18.78	3.74; -6.04–13.52	234.33; -171.16–639.82
2. Spring barley	-	-	-
3. Peas	-	-	-
4. Spring barley + *E. repens*	1.67; -0.25–3.59	1.36; -0.62–3.34	79; 2.96–155.04
5. Peas + *E. repens*	1.19; -2.44–4.82	0.89; -2.29–4.07	26.67; -45.21–98.55
6. Spring barley (50%) + peas (50%)	-	-	-
7. Spring barley (50%)+ peas (50%) + *E. repens*	0.69; -0.86–2.24	0.45; -0.62–1.52	23.67; -27.98–75.32

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