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Weed Control with Straw Residues in Occasional Direct Seeding of Faba Bean (*Vicia faba* sp.) in Organic Agriculture

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Key words: no-tillage system, precrop oats, firm soil mulch husbandry, Organic Farming

ABSTRACT

In order to gain momentum in the consolidation process of no-tillage systems in Europe's Organic Agriculture, occasional direct seeding (DS) of faba bean (FAB) into a mulch layer of residues from precrop oats should be scrutinized. In contrast to non-legumes, grain legumes do not depend on soil-borne nitrogen due to their ability to fix nitrogen symbiotically. Concerning weed infestation, straw residues left by precrops may at least physically suppress weeds. In order to prove this hypothesis, two field experiments were carried out in 2009 at two sites in the lower Rhineland region, Germany. DS treatments were combined with 0, 4, and 6 t ha^{-1} of straw residues. Mouldboard ploughing (MP) combined with conventional seedbed preparation was used as control. Compared to the DS treatment without straw residue (0 t ha^{-1}), DS treatments with straw residues (4 and 6 t ha^{-1}, resp.) resulted in significantly lower weed density (70 and 84 % resp.). Neither differences were observed in both shoot dry matter of FAB and weeds for DS with straw residues compared with MP, nor for the grain yields of FAB. We conclude that occasional DS of FAB in OA is successful to reduce annual weeds sufficiently and may not lead to reduced FAB yields.

INTRODUCTION

Aims of reducing tillage intensity include to prevent soil compaction and erosion, to improve top soil trafficability and to save labour and energy costs (Pekrun and Claupein 1998). Moreover, non-inverting tillage procedures usually show higher microbial activity and microbial biomass in the 0-10cm soil layer compared with ploughed soils (Doran 1987, Berner *et al.* 2008). However, in Organic Agriculture (OA) in the European temperate climate, the use of loose soil husbandry (LSH) – mostly performed with the mouldboard plough (MP) - is still the common soil tillage system (Köpke 2003). Only a few organic farmers in Central Europe use the extreme option of firm soil mulch husbandry (FSMH), i.e. direct seeding (DS), mainly due to two reasons: (i.) under temperate climate conditions omitting deep loosening and inversion of the topsoil results in cooler wetter soils in early spring, reducing mineralization and nitrification of soil-borne nitrogen, as well as its transformation into crop yield of non-leguminous crops. (ii.) LSH, in particular ploughing, is an effective tool to control annual and perennial weeds (Köpke 2003). In contrast to mainstream farmers, synthetic herbicides are not allowed to be used in OA, also their natural counterparts (e.g. natural vinegar, corn gluten, pine wood extracts) that are officially certified in other regions of this globe, are currently not considered as adequate to be used in Europe's OA (Kühne *et al.* 2005). In contrast to non-legumes, grain legumes as FAB do not depend on soil-borne nitrogen due to their ability to fix nitrogen symbiotically. For crop establishment their demand for

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water is high. Thus, FAB are well-adapted to the wetter no-tilled soil in early spring. During the later stages of crop development FAB possess a high competitiveness against weeds.

Mulch layers of precrops may suppress weeds. For efficient weed suppression Barberi (2002) considers homogeneous distribution of at least 4-6 t ha^{-1} crop residues necessary. Additionally, allelopathic action of some oats genotypes has been assumed (Chou 1986). For the conditions of European temperate climate, competitiveness of yellow oats (*Avena sativa* L.) is considered as relatively high when compared with other cereals (Davies & Welsh 2001). Based on this approach we set up field trials after precrop yellow oats in order to test the following hypotheses: (i.) Occasional direct seeding of FAB into a mulch layer of precrop oats enables sufficient control of annual weeds; (ii.) Direct seeding of FAB in OA is not possible, unless the weed infestation is sufficiently suppressed.

MATERIALS AND METHODS

Two one-factorial field trials with four replicates were carried out in 2009 at the organic research farm Wiesengut (WG) of the University of Bonn in Hennef (Germany) on a clayey-silty to sandy-silty floodplain sediment (fluvisol, 50°48´ N, 7°17´ E; 62 m a.s.l.; mean annual temperature 10.3°C; mean annual precipitation 840 m). A second trial was conducted in the same year under the conditions of low weed pressure at the conventional experimental farm Frankenforst (FF) of the University of Bonn in Königswinter (Germany) on a stagnic luvisol derived from loess (50°42' N, 7°12' E; 182 m a.s.l.; mean annual temperature 9.0°C; mean annual precipitation 700 m). DS-treatments were diffferenciated by the amount of straw residues: 0, 4, 6 t ha^{-1}, resp. Mouldboard ploughing (MP) combined with conventional seedbed preparation, an oil radish winter cover crop, ploughing and seed bed preparation in early spring was used as control. FAB were sown on March 21 and April 7 at site WG (85 grains m^{-2}) and FF (45 grains m^{-2}) respectively, by using a direct seeding machine type SEMEATO SHM 11/13. Weed density of annuals (individuals m^2) was determined on February 26 and April 09 at WG as well as on March 10 and May 05 at FF in 0.1 m^2 subplots with four replicates per plot. Dry matter of weeds and FAB were determined 88 DAS by harvesting the shoot mass in ½ m^2 subplots, with two replicates per plot. Grain yields were determined 130 DAS by harvesting an area of 10 m^2 and 20 m^2 per plot at WG and FF, respectively. ANOVA was performed by using SPSS (version 18) followed by Shapiro-Wilk's test. For analysis of variance (ANOVA) means were compared using the Scheffé's test.

RESULTS AND DISCUSSION

According to our hypothesis, increased amount of straw residues in DS treatments resulted in significantly lower density of annuals (Fig. 1). Compared with the DS treatment without straw residue (0 t ha^{-1}), DS treatments with straw residues (4 and 6 t ha^{-1}) resulted in a decrease of weed density by about 70 to 84%. Despite the weed controlling effect of MP, the weed density in DS treatment 6 t ha^{-1} was considerably lower than the density in the control. DS treatments with straw residues (4 and 6 t ha^{-1}) showed lower weed dry matter compared with DS without straw. Nevertheless, only the DS 6 t ha^{-1} treatment was significantly different from the DS 0 t ha^{-1} treatment (Fig. 1). Both DS treatments with straw residues were not significantly different from the MP control. As expected, both weed parameters showed a considerable weed suppression effect as a function of the amount of straw left in the field. These results confirmed previous studies on the effectiveness of weed suppression by increasing soil coverage (e.g. Bilalis et al. 2003). In agreement to Barberi (2002), efficient weed suppression can be achieved with straw residues amounting at least 4 t ha^{-1}.

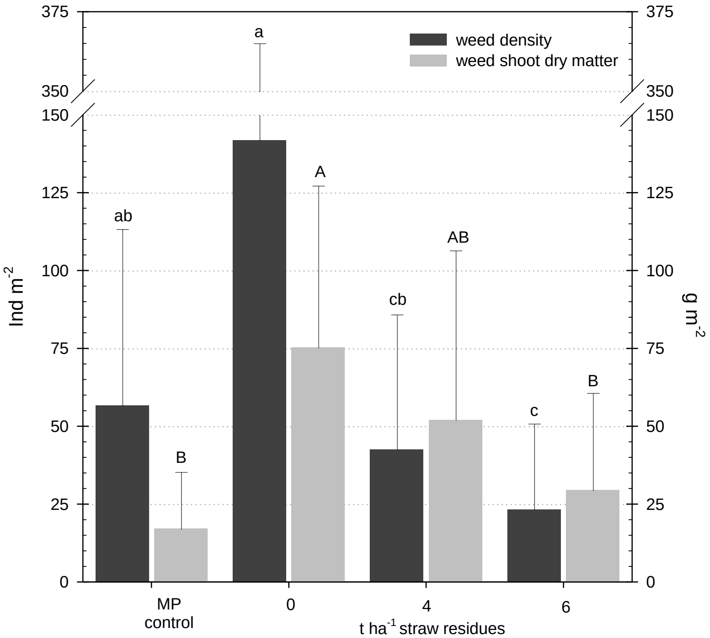

FIG 1: WEED DENSITY ±SD (IND. M^{-2}) AND WEED SHOOT DRY MATTER ±SD (G M^{-2}) IN FABA BEAN, AS AFFECTED BY TILLAGE TREATMENT: MOULDBOARD PLOUGHING (CONTROL), AND DIRECT SEEDING (DS) INTO STRAW RESIDUES OF 0, 4 AND 6 T HA^{-1}, RESPECTIVELY. DIFFERENT LETTERS SHOW SIGNIFICANT DIFFERENCE (SCHEFFÉ TEST, A<0.05).

The lower shoot dry matter and grain yields of FAB in DS plots without straw (0 t ha^{-1}) compared with DS treatments with straw residues (4 and 6 t ha^{-1}), although not significant (Tab. 1) may at least partly be the result of the early competition by the annuals. No significant yield differences were determined between MP and DS treatments with straw residues, in contrast to the DS treatment without straw. Reduced weed pressure and vigorous growth of FAB enabled DS treatments with straw residues (4 and 6 t ha^{-1}) to increase the grain yield by0.2 and 0.4 t ha^{-1}, respectively. Concerning previous results (Köpke 2008), costs for labour and fuel inputs were more than five-fold higher in MP compared with DS. Based on these results a0.5 t ha^{-1} lower grain yield could be accepted for the DS treatments before equalizing the gross margin of the MP treatment.

TAB 1: SHOOT DRY MATTER ±SD AND GRAIN YIELD ±SD OF FABA BEAN AS AFFECTED BY TILLAGE TREATMENT: MOULD-BOARD PLOUGH (MP, CONTROL), DIRECT SEEDING (DS) INTO MULCH RESIDUES (0, 4 AND 6 T HA^{-1}). DIFFERENT LETTERS SHOW SIGNIFICANT DIFFERENCES (SCHEFFÉ TEST, A<0.05).

	MP	oDS in straw residues (t ha^{-1})		
	control	0	4	6
Shoot dry matter (t ha^{-1})	10.0 ± 1.5 **a**	8.1 ± 1.5 **b**	9.1 ± 2.1 **ab**	9.7 ± 1.9 **ab**
Grain yield (t ha^{-1})	3.1 ± 0,8 **ab**	2.9 ± 0.5 **b**	3.1 ± 0.7 **ab**	3.3 ± 0.6 **a**

CONCLUSIONS

Occasional DS of FAB into mulch layers of the precrop oats enables successful weed control of annuals. This DS system can be considered a suitable approach to save labour and fuel, where perennial weeds do not play an important role or can be accepted due to sufficient crop competitiveness. Failure of clear effects of weed suppression of perennials makes further investigations necessary.

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