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EFFECTS OF MECHANICAL WEED CONTROL IN ORGANIC SOYBEAN CULTIVATION ON YIELD AND WEED BIOMASS IN LUXEMBOURG

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Abstract: Organic soybean cultivation in Luxembourg is still in its initial stage, with knowledge gaps mainly in mechanical weed control. Within the framework of the project LeguTec, five weed control methods in soybean cultivation are tested under real conditions on three organic farms distributed over Luxembourg in 2018 and 2019. The focus lies on treatments with a harrow, hoe, finger weeder, mixed cropping and combination. The field trials are conducted in four replicates including control plots. Different rating parameters are taken before and after each weed treatment as well as at flowering and at harvest to assess the efficiency of the used technique in relation to yield. First results of the two years show higher yields and less weed biomass at flowering in hoeing treatments than in harrowing treatments. Significant correlations can be derived from yield and weed biomass at flowering.

Introduction: Characterised by a protein content of about 40 % and a very high biological value due to an ideal amino acid composition, soybean (*Glycine max* (L.) Merr.), a member of the family *Leguminosae*, is one of the most important feed protein sources in animal nutrition (Bernet et al. 2016). By signing the European Soy Declaration (2017), Luxembourg aims to promote the regional cultivation of soybeans and other protein crops. However, the organic cultivation of soybean is demanding and there are knowledge gaps in efficient, sustainable weed management in Luxembourg (Zimmer et al., 2016). The aim of the project "Sustainable and resource-efficient protein production using various mechanical weed control methods in grain legume cultivation, using soybean as an example" (LeguTec) is to investigate the efficiency of the selected mechanical systems under consideration of, inter alia, weed biomass.

Material and methods: In 2018 and 2019 five mechanical weed control methods in soybean cultivation (variety Merlin) are tested and compared under real conditions on three organic farms distributed among Luxembourg (Manternach: temp. 9.8°C, prec. 617 mm, 281 m above sea level; Sprinkange: temp. 9.7°C, prec. 681 mm, 336 m above sea level; Hostert: temp. 9.1°C, prec. 921 mm, 464 m above sea level). The field trials are implemented each as a one-factorial-exact-trial with four replicates. The mechanical treatments include A) harrow, B) interrow cultivator with duck foot shares, C) interrow

cultivator with duck foot shares and finger weeder, D) a flexible system, a combination of treatment A and C, while the decision is made according to the actual site and weather conditions and E) mixed cropping of soybean and camelina in combination with harrow. When weather conditions allow it, blind-harrowing is carried out in A, D and E. A positive control (F), where all weed is taken out by hand and a negative control (G), where no weed control is administered, are considered as well. Weed biomass is cut out before and after each weed treatment as well as at flowering and at harvest to assess the efficiency of the used technique in relation to yield. Data were analysed using ANOVA ($p < 0.05$). When significant treatment effects were indicated by ANOVA, pairwise comparisons of treatments were conducted using Fisher's LSD test ($p < 0.05$).

Results: In 2018 the field trial Sprinkange shows significantly higher yields and less weed after blind harrowing with subsequent hoeing with hoe and finger weeder (D) than with harrowing (A and E) (see table 1). Significant less weed biomass is observed in Hostert for D in comparison to A and E, too. Yields do not differ significantly between treatments but show a tendency towards higher yields with hoeing. No significant differences in yield and weed biomass are observed in Manternach. In 2019, significant higher yields are found with hoeing B and C as opposed to A for Manternach and with all hoeing treatments as opposed to all harrowing treatments (A and E) for Sprinkange. Biomass in Manternach is significant smaller in combination D. Yield and weed biomass at flowering show significant correlations (Pearson correlation, $p < 0.05$) in 2018 of $r = -0.72$ (Sprinkange), $r = -0.86$ (Hostert) and in 2019 of $r = -0.41$ (Manternach).

Discussion: Soybean yield tend to be higher and weed biomass at flowering tend to be lower in the hoeing treatments than in the comparative harrowing treatments. Weed biomass at flowering negatively correlates with yield and indicates the success in weed control. At the Manternach site, weed pressure was low throughout the season 2018, allowing good regulation in all treatments. High weed pressure from the beginning on limits yields in all treatments in Hostert but with a tendency towards weed control in favor of the hoe. The summer drought in 2018 led to yield losses at all the study sites. Soybean had to go into emergency ripening in Manternach, where 15 % of the pods opened before harvest. Results from the third missing field trial of 2019 will complement the study and will be presented at the Organic World Congress 2020. The increased interest in regional soybean cultivation in Luxembourg due to the LeguTec project shows the need of further research on soybean cultivation to reach the long-term goal of overcoming cultivation barriers and promoting a sustainable, resource-efficient protein production in Luxembourg.

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Image:

2018	Manternach				Sprinkange				Hostert			
	Biomass		Yield		Biomass		Yield		Biomass		Yield	
Var.	weed [g m ⁻²]		[t ha ⁻¹]		weed [g m ⁻²]		[t ha ⁻¹]		weed [g m ⁻²]		[t ha ⁻¹]	
(A)	9.2	a	1.38	a	98.7	d	1.03	d	344.1	d	0.76	bc
(B)	8.9	a	1.40	a	33.4	bc	1.39	ab	276.9	bc	1.01	bc
(C)	10.0	a	1.48	a	25.8	b	1.39	ab	293.1	bcd	1.00	bc
(D)	15.0	a	1.39	a	23.6	ab	1.41	ab	254.7	b	1.04	b
(E)	19.2	a	1.28	a	119.2	d	1.12	cd	333.9	cd	0.75	bc
(F)	0.0	a	1.36	a	0.0	a	1.62	a	0.0	a	1.55	a
(G)	101.2	b	1.18	a	58.4	c	1.27	bc	411.6	e	0.67	c

2019	Manternach				Sprinkange			
	Biomass		Yield		Biomass		Yield	
Var.	weed [g m ⁻²]		[t ha ⁻¹]		weed [g m ⁻²]		[t ha ⁻¹]	
(A)	32.2	ab	0.72	c	204.8	a	0.75	b
(B)	33.2	ab	1.31	ab	149.3	a	1.25	a
(C)	32.3	ab	1.44	a	210.8	a	1.25	a
(D)	16.2	a	1.26	abc	162.3	a	1.45	a
(E)	64.0	bc	0.78	bc	177.3	a	0.71	b
(F)	0.0	a	0.78	bc	NA	-	NA	-
(G)	82.1	c	0.81	bc	252.0	a	0.54	b

Table 1: Yield [t ha⁻¹] and weed biomass at flowering [g m⁻²] for the three study sites in relation to the different treatments A – G for the observation years 2018 and 2019; n = 4; different letters indicate significant differences (ANOVA, Fisher`s LSD, p<0.05).

Disclosure of Interest: None Declared

Keywords: LeguTec, Luxembourg, mechanical weed control, organic agriculture, Soybean