Organic World Congress 2020 | FRANCE

SEPTEMBER 21ST TO 27TH, 2020 IN RENNES
AT THE COUVENT DES JACOBINS • RENNES MÉTROPOLE CONFERENCE CENTRE
www.owc.ifoam.bio/2020

OWC 2020 Paper Submission - Science Forum

Topic 4 - Innovation in Organic farming: "thinking out of the Box"

OWC2020-SCI-712

SUNFLOWER ASSOCIATED WITH LEGUMES-BASED COVER CROP: A WAY TO INCREASE NITROGEN AVAILABILITY FOR THE FOLLOWING WINTER WHEAT?

Cécile Le Gall* [1], Mathieu Gazzola[2], Arnaud Micheneau[3], Régis Hélias[4]

[1]Terres Inovia, Thiverval Grignon, [2]Terres Inovia, Montesquieu Lauragais, [3]Terres Inovia, Agen, France, [4]Arvalis-Institut du Végétal, Montans

Preferred Presentation Method: Oral or poster presentation

Full Paper Publication: No

Abstract: Sunflower is one of the most important crop of organic crops systems in the South of France. In this region, sunflower is mostly cultivated before soft winter wheat, which is very often deficient in nitrogen because of a lack of nitrogen in the soil when the wheat needs it. To increase the soil nitrogen availability, one way is to introduce a legumes-based cover crop before wheat, which is sown just after the previous crop harvest. Thus, the time between sunflower harvest and wheat sowing is often too short to produce enough biomass. An alternative is to sow the cover crop during the sunflower cultivation, so to be intercropped into it. In a trial repeated over 3 years (from 2015 to 2017) in the southwest of France, Terres Inovia tested this practice, by intercropping 3 kinds of legumes-based cover crops into sunflower: alfalfa, purple vetch and legumes mixture. Over the 3 years, the growth of the cover crops was satisfying, and the average amount of nitrogen returned to soil after cover crops destruction was of 40 kg N/ha for purple vetch, 18 kg N/ha for alfalfa and 19.5 kg N/ha for legumes mixture. Nevertheless, cover crops impact severely sunflower performance because of competition for water and poor weed control due to no hoeing. Sunflower yield was reduced on average by 45% over the 3 years. This economic loss was partially compensated by a benefit on wheat yield, which was observed in 2016 and 2018, but only for wheat following sunflower intercropped with alfalfa.

Introduction: Sunflower is one of the most important crop of organic crops systems in the South of France and is mostly cultivated before soft winter wheat (on 47% of the sunflower cultivated area). In organic systems, soft winter wheat is often deficient in nitrogen. The wheat nitrogen status is closely related to nitrogen availability in soil during wheat cultivation, which can be improved by introducing legumes-based cover crop in the crop rotation (with high nitrogen content residues returned to soil). Nevertheless, for wheat following sunflower, it is very difficult to introduce a cover crop because the time available between the 2 crops is very short. An alternative practice would be to sow the legumes-based cover crop earlier, during the sunflower cultivation period.

However, this practice, barely tested in France, can have negative impacts on sunflower. Firstly, the cover crop can compete with the sunflower, for light and water. Secondly, it prevents from using hoe or harrow comb for weeding because it would destroy the cover crop; weed management so depends entirely on the cover crop ability to compete with weeds. These can result in a reduced yield for sunflower, and an economic loss. This has to be put into balance with the profit obtained on the following wheat, on yield and grain protein content.
Terres Inovia tested this practice in an experiment repeated over 3 years in Occitanie, firstly to assess its feasibility in the Southern France production context, secondly to evaluate the impacts on sunflower growth and yield, and lastly to estimate the gains on the yield and grain quality of the following wheat.

Material and methods: One single trial was repeated over three years in the Tarn department in the region Occitanie; trial was conducted in randomized blocks design (3 repetitions per treatment). Each trial was conducted in an organic farm, and not on an experimental station; consequently, plots were very large (from 117m² to 191 m²).
Sunflower was sown between the beginning and the middle of May. The trial compared a sunflower sown alone (the control treatment) and three intercropped treatments (with legumes): alfalfa (20 kg/ha), purple vetch (80 kg/ha), Egyptian clover in 2015, and then legumes mixture (chickling vetch, common vetch, fenugreek and lens - 25 to 30 kg/ha) in 2016 and 2017.
In 2015, alfalfa was sown just after sunflower, but purple vetch and Egyptian clover were sown one month after to allow weeding by hoeing before their sowing. However, with almost no precipitations in July 2015, the cover crops emergence was greatly compromised. As these weather conditions are common in Occitanie, it was decided the next years to sow the cover crops earlier.
The control treatment was hoed one single time on each year. For the treatments with legumes-based cover crop, no weeding was done except in 2015. Except ferric phosphate to avoid slugs' damages, no plant protection products were used. Sunflower was also not fertilized. For each trial, soft winter wheat was sown on each plot after sunflower harvest and cover crop destruction.
To assess the effects of the cover crops on sunflower, several measurements were done: sunflower height at flowering (to detect water competition), cover crop biomass and nitrogen content, weed biomass and sunflower yield.
To assess the effects of the cover crops on soft winter wheat, several measurements were done: soil nitrogen contents at 3 dates, wheat biomass and nitrogen content at wheat flowering, wheat yield and grain protein content.

Statistical analyses were done using R version 3.5.1. Effects on the different treatments were tested through a mixed linear model with factors "trial" and "repetition" introduced as random effects. Comparison between treatments was done through Tukey Test (alpha=0.05).

Results:

Do cover crops grow strongly?

In 2015, the fresh biomass of cover crops was correct: between 1.7 T/ha for alfalfa to 4.2 T/ha for purple vetch. In 2016, alfalfa fresh biomass reached 1.8 T/ha whereas purple vetch and legumes mixture reached 3.6 and 3.2 T/ha respectively. In 2017, fresh biomass was smaller: 1 T/ha for alfalfa, 1.2 T/ha for vetch purple whereas legumes mixture reached only 0.1 T/ha.

Do the cover crops limit weed development in sunflower?

In 2015, weed infestation was very low, due to high drought in spring. On the contrary, in 2016 and 2017, weed infestation by switch grass was important: on the control treatments, measured weed drought biomass was of 250 g (+/- 64 g) in 2016 and of 100 g/m² (+/-64 g) in 2017. In comparison, weed biomass on intercropped treatments was much important:300 g/m² (+/-80 g) in 2016 and of 700 g/m² (+/-475 g) in 2017. Statistical analyses show that the differences observed in 2016 between the control treatment and the intercropped treatments were significant whereas they were not in 2017. For the two years, the legumes mixture was the most infested. These results show that the cover crops did not manage to control weeds development.

Do the cover crops compete with sunflower for light and water?

In 2016 and 2017 an important impact on sunflower height was observed: in 2016, the control treatment height was of 164 cm (+/- 5cm) instead of 144 to 157 cm for the intercropped treatments (+/-10 cm) and in 2017, the control treatment, sunflower height was of 135 cm (+/-3cm) whereas it ranged from 107 to 114 cm for the intercropped treatments (+/-6 cm). In 2016, statistical analyses show that the differences observed are significant for purple vetch and alfalfa intercropped into sunflower (compared to control treatment) but not for legumes mixtures; in 2017, with less important raindrops compared to 2016, the differences observed are significant for all the intercropped cover crops treatments compared to control treatment.

This competition was due as much to the cover crop itself than to the weed's development on the intercropped treatments. Indeed, on intercropped treatments in 2016, the mean total fresh biomass (cover crop + weed) was of 696 g/m² for intercropped treatments instead of 283 g/m² for the control treatment; and in 2017, the difference was much important : 832 g/m² for the intercropped treatment compared to 102 g/m² only for the control treatment. This competition greatly impacted sunflower yield, as it is shown in the figure below:

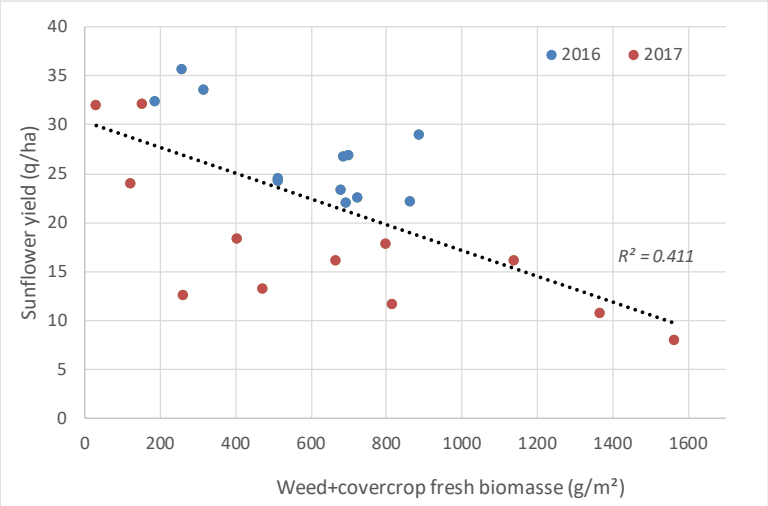

Figure 1 - Impact of cumulated cover crop and weed biomass on sunflower yield

Do the cover crops limit or improve sunflower yield?

Sunflower yield was not measured in 2015. In 2016, the yield of the control treatment was higher (33.7 q/ha +/- 1.6 q/ha) than the yield of intercropped treatments (from 22.2 q/ha +/- 0.3 for purple vetch to 27.4 q/ha +/- 1.2 for the legumes mixture). In 2017, the differences were larger: 29.3 q/ha +/-4.6 for the control treatment whereas it ranged from 13.1 q/ha (+/- 2.7) to 14.1 q/ha (+/-3.8) for the intercropped treatments. For both years, statistical analyses show that the yield obtained for the control treatment is significantly different from the intercropped treatments (see table below):

Year	Treatment	Sunflower yield	Statistical group
2016	Alfalfa	24	A
	Purple Vetch	22	A
	Legumes mixture	27.4	B
	Control (sunflower alone)	33.8	C
2017	Alfalfa	13.1	A
	Purple Vetch	14.2	A
	Legumes mixture	14.1	A
	Control (sunflower alone)	29.3	B

Table 1 - Sunflower yields and statistical analyses

Do the cover crops improve the soil nitrogen availability for the following wheat?

Over the 3 years, purple vetch is the cover crop which returned the most nitrogen to the soil over the 3 years (40 kg N/ha in average), following by legumes mixture (19.5 kgN/ha) and alfalfa (18 kg N/ha). Nevertheless, the nitrogen "bonus" was never found through soil nitrogen content measurements during wheat cultivation.

Do the cover crops improve the following wheat yield and grain quality?

Nitrogen absorption by the wheat was slightly improved by alfalfa cover crop, and particularly in 2018 with 114 kg N/ha absorbed compared to 100 kg N/ha for the control treatment.

In 2017, following the sunflower cultivated in 2016, no significant differences were found on the yield of the wheat between the treatments. On the contrary in 2018, the wheat following the sunflower intercropped with alfalfa obtained a very good performance with a yield of 37 q/ha (+/- 2.5) compared to a yield of 27.1 q/ha (+/- 5.5) for the wheat following the sunflower alone; the yield of the other treatments were however very closed to the control treatment. In 2015, we obtained also a difference with wheat following sunflower intercropped with alfalfa (+5.6 q/ha). The statistical analyses show that the differences between the treatments were not significant in 2015 and in 2016; in 2017, the difference was significant only for the wheat following alfalfa, which was significantly higher than the wheat following the sole sunflower (see table below). Concerning wheat grain nitrogen content, no improvement was observed over 2016 and 2017.

Year	Treatment	Wheat yield (q/ha)	Protein grain content (%dry weight)	Statistical group for yield	Statistical group for protein grain content
2015	Alfalfa	26.6	-	A	-
	Purple Vetch	22.4	-	A	-
	Clover	23.1	-	A	-
	Control (sunflower alone)	21.3	-	A	-
2016	Alfalfa	49.6	9.8	A	A
	Purple Vetch	50.7	9.9	A	A
	Legumes mixture	48.4	9.9	A	A
	Control (sunflower alone)	47.3	9.7	A	A
2017	Alfalfa	37.4	11.3	B	A
	Purple Vetch	27.5	11.3	AB	A
	Legumes mixture	24.2	11.3	A	A
	Control (sunflower alone)	27.1	12	AB	A

Table 2 - Wheat yield and protein grain content and statistical analyses

Discussion:

Intercropping legumes into sunflower is relatively new in France but not in other parts of the world; particularly, intercropping with soybean was often tested (Elba et al, 2014; Ibrar et al, 2002; Narwal et al, 1985) with the view to harvest the two species and increase the total biomass produced on the field (Bedoussac et al, 2013). However, our aim in this study was slightly different since we did not want to harvest legumes, but we wanted yet to have the most important biomass produced, to maximize the nitrogen amount returned to the soil.

Our results over 3 years show that to intercrop sunflower with legumes-based cover crops is feasible. Nevertheless, this practice is not without impacts on sunflower, with a strong competition for light and water observed over 2 years, which induced a yield loss of 40% to 50%.That implies a severe economic loss for the producer, which was not compensated by the profit obtained on the following wheat, even in 2018 (loss on sunflower : 67.5 euros/ha - gain on wheat: 40 euros/ha). Kandel et al (1997) obtained the same results, with an important yield loss for sunflower for the 4 legume species which were tested, when they were sown at the same date than sunflower; similar trends were observed by Ibrar et al (2002) and Narwal et Malik (1985). Concerning the impact of legume cover crops on wheat, Kandel et al (2000) obtained the same trends than in our studies, with a slightly positive and significant effect, at least for some species; in their study, wheat following hairy vetch obtained each year a better yield than wheat following sole sunflower (difference was significant for 2 years only among 4).

It is nevertheless difficult to conclude with only a 3-years trial. Observations must be made in other situations to confirm (or not) the trends observed in our trials. An important question is the choice made for the cover crop sowing date. Indeed, in these trials, we chose to sow the cover crops at the same time as the sunflower, to maximize the cover crop growth and the nitrogen budget for the following wheat. By sowing the cover crop later, and after the hoeing, we could have preserved the sunflower performances and, after all, could have observed a positive effect on wheat yield. The results obtained by Kandel et al (1997, 2000) show that, by sowing the cover crops at V4 or V10 stage of sunflower, impacts of cover crops on sunflower yield are reduced, even if the yield of the sunflower intercropped with legumes was still lower. The offset of the cover crop sowing date also impacted their positive effect on the following wheat, which was reduced by 5% to 13%. Finally, the competition for water observed in our situation could be reduced in other pedoclimate conditions, with more precipitations and less high temperature in summer, like in Northern France where sunflower is also present. Tests on this practice have so to be continued.

References:

BEDOUSSSAC, L., CHAMPCLOU, D., TRIBOUILLOIS, H., VERICEL, G., LANDE, N., & JUSTES, E. (2013). Soybean intercropped with sunflower is an efficient solution to increase global grain production in low input systems. LEGUME, 16, 45.

Elba, B., Suárez, S. A., Lenardis, A. E., & Poggio, S. L. (2014). Intercropping sunflower and soybean in intensive farming systems: evaluating yield advantage and effect on weed and insect assemblages. NJAS-Wageningen Journal of Life Sciences, 70, 47-52.

Kandel, H. J., Schneiter, A. A., & Johnson, B. L. (1997). Intercropping legumes into sunflower at different growth stages. Crop science, 37(5), 1532-1537.

Kandel, H. J., Johnson, B. L., & Schneiter, A. A. (2000). Hard red spring wheat response following the intercropping of legumes into sunflower. Crop science, 40(3), 731-736.

Ibrar, R., Ahmad, S., & Malik, M. A. (2002). SUNFLOWER-SUMMIER LEGUMIES INTERCROPPING SYSTEMIS UNDER RAINFED CONDITIONS: YIELD AND YIELD COMPONENTS. Pakistan J. Agric. Res. Vo1, 17(3).

Narwal, S. S., & Malik, D. S. (1985). Influence of intercropping on the yield and food value of rainfed sunflower and companion legumes. Experimental agriculture, 21(4), 395-401.

Image:

Disclosure of Interest: None Declared

Keywords: cover crop, nitrogen availability, sunflower