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SPECIES MIX AS COVER CROP TO PRACTICE NO TILLAGE IN ORGANIC ARABLE PRODUCTION

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Abstract: Cover crop no tillage (CCNT) technique could provide a diversity of benefits on soil quality in organic production system including spring cash crop such as soybean. However, CCNT remains poorly practiced by organic farmers due the challenges to manage weeds and cover crops without neither soil tillage nor herbicide. This paper aims to investigate the effect of a mix of cereal grains as cover crop compared to pure species to reduce weed pressure and the effect on soybean in organic CCNT system. Trials were conducted at four locations in France to compare three cover crops: rye, triticale and mix of rye/triticale. The cover crops are rolled and soybean is directly planting into the mulch. The mix of rye/triticale cover crop conducted to an intermediate weed control between the pure species from the soybean planting to the harvest. The mix of rye/triticale as rolled cover crop provided similar soybean yield than with pure rye (2.5 $t.ha^{-1}$) which is superior to the soybean yield obtained with triticale cover crop (2.0 $t.ha^{-1}$).

Introduction: Cover crop no tillage (CCNT) appears as an alternative practice to intensive soil tillage for limiting soil degradation observed in organic soybean production, managing weeds and saving labor and energy consumption. The CCNT involves the direct seeding of cash crop into cover crop terminated by rolling. There are few references and the cover crop choice remains as one of the first challenge to be addressed for both managing weeds and being managed by rolling (Vincent-Caboud et al. 2017, 2019a). While previous studies have demonstrated the ability of rye (Secale cereale L.) cover crops to suppress weeds (Mirsky et al. 2013), the success of the CCNT is still highly variable across years and location. In addition, according to the location, rye seeds remain more expensive and difficult to access than others cereal grain species. The objective of this study is to examine the performance of a mix of cereal grain species on weed suppression and soybean [Glycine max (L.) Merr.] in an organic CCNT system production.

Material and methods: Four trials were conducted on certified organic land between 2016 and 2018 in Southern France Rhône-Alpes region characterized by temperate climate with consistent cool conditions and lower precipitation. Each trial was carried out on a different site: A (Drôme), B (Northwestern Isère), C (Ain) and D (Northeastern Isère) (Vincent-Caboud et al. 2019b).

Three cover crops were compared (rye, triticale and mix of rye/triticale [x Triticosecale Wittmack]) using a randomized complete block design with four replications. The sites were 0.35 ha fields with 24 x 12 m^2 sub-plots. Cover crops were

planted at the end of summer of 2016 and 2017 at 200 kg.ha^{-1}. Roller-crimpers were used to terminate the cover crops before the soybean planting (**Figure 1**). Soybean was planted at 568,000 seed.ha^{-1} when cover crops reached 50 % to 100 % anthesis (Zadoks growth stage 65-69) which happened from May 16 to May 29 all years.

Weather data was obtained from individual stations by site. Cover crop height was recorded on 20 randomized plants per plots. Cover crop and weed biomass were estimated by collecting aboveground biomass in four randomized 0.5 x 0.75 m² quadrats per plots before cover crop rolling. The samples were dried at 80°C until constant weight. With similar method, weed biomass was determined in September prior to soybean harvest. Soybean stands were determined by counting population on three randomized four linear meters portions of the rows within three weeks after planting. Soybean height was measured on 15 randomized plant per plots at the mid-flowering stage. To estimate yields, soybean aboveground biomass and grain weight were measured on two linear meters. Samples were replicated 3 times per plot.

Linear mixed models were used to evaluate the effect of rye, triticale and mix of rye/triticale cover crops on cover crop height and biomass, weed biomass and soybean population, biomass and yield. “Cover crop species” was treated as a fixed effect. The 4 sites and 12 plots per sites were treated as a random effect. The “site” factor refers to “location x year”. The following model was used for analysis:

$$Yijk=Xi+Aj+Bk+Cjk+XEijk$$

where X is the fixed factor (cover crop), A the first random effect (sites), B the second random effect (plots), C the interaction between both random effect factors, XE the error term, i a particular cover crop specie, j a particular site (location x year) and k refer to a particular plot.

Cover crop height, soybean height and yield met the assumptions for analysis of variance. Cover crop biomass, weed biomass, as well as soybean density and biomass, were transformed as needed to meet the assumption for analysis of variance using square root transformation. We used the R software for every statistical analysis in R version 1.1.463 © RStudio, Inc, and more precisely the lme4 package for the linear mixed models. Statistical significance of the results was evaluated at a *p-value* < 0.05 and treatment means were compared using Tukey’s pairwise comparison.

Results: Results did not show significant difference in biomass production between rye, triticale and mix of rye/triticale cover crops with respectively 5683 kg.ha^{-1}, 4142 kg.ha^{-1} and 5370 kg.ha^{-1}. However, rye and the mix cover crops grew taller than pure triticale with respectively 122 cm, 108 cm and 76 cm ($p < 0.001$). Data from the four trials indicate high level of cover crop biomass variability according to year and location with range biomass from 2963 kg.ha^{-1} at site B for cereal specie to 9988 kg.ha^{-1} at site A for rye specie.

Throughout the season, from the soybean planting to the harvest, triticale mulch ensure the lowest weed control compared to the other mulches with more than 2040 kg.ha^{-1} of weed biomass at soybean harvest ($p < 0.001$) (**Table 1**). The Tuckey’ test indicates an intermediate performance of the mix rye/triticale cover crop between the pure rye and triticale species ($p < 0.001$). Data from the four trials shows high variability according to the sites (year x location) (**Table 1**). For example, in the site A, we success to manage the weed development between soybean planting and harvesting while at the site C, the weed biomass was increasingly higher at harvest compared to the soybean planting period with a mean of 3374 kg.ha^{-1} of additional dry matter whatever the cover crop.

Table 1: Weed biomass through soybean planting to harvest according to the rolled cover crop species

Sites	Weed biomass at soybean planting (kg.ha^{-1})			Weed biomass at soybean harvest(kg.ha^{-1})		
	Rye CC	Triticale CC	Rye x triticale CC	Rye mulch	Triticale mulch	Rye x triticale mulch
A	402	1119	686	319	857	779
B	327	177	483	1245	1270	1510
C	317	639	416	3479	4445	3571
D	134	163	163	1683	1554	1810
Mean[1]	**295c**	**525a**	**437b**	**1682c**	**2032a**	**1918b**
p-value	< 0.001			< 0.001		

CC: Cover crop before the cover crop rolling

Mulch: Cover crop following the cover crop rolling

*Linear mixed model, n = 72, Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.*

[1] *Mean from data of the 4 sites*

Each cover crop (rye, triticale and/or rye x triticale) followed by same letter are not significantly different (n=72).

Results did not indicate significant difference of soybean stand according to the cover crop but soybean losses were observed at emergence stage. A mean of 325,000 plant.ha^{-1} was determinate; i.e., 42 % of soybean stand losses. At mid-flowering of soybean, soybean height of mix rye/triticale mulch was greater than pure triticale mulch with respectively 49 cm and 46 cm ($p < 0.01$). Pure rye specie and mix of rye/triticale mulches conducted to a significant higher soybean yield than pure triticale mulch, with respectively 2.50 t.ha^{-1}; 2.54 t.ha^{-1} and 2.08 t.ha^{-1} ($p < 0.001$) (**Figure 2**).

Discussion: The mean of the cover crops biomass before rolling was low (< 6000 kg.ha^{-1}) compared with others North American studies where cover crop biomass can reach more than 8000 to 10,000 kg.ha^{-1} (Mirsky et al. 2013). Multi-tactic approach has to be studied to improve the cover crop productivity facing the climate change including seeding rate, cultivar, date sowing and fertilization. This study indicates that the cover crop choice with allelopathic effect such as rye is fundamental to improve the weed control and soybean yield. Similar weed control is obtained between mix of rye/triticale species and pure rye. Species mixture could provide improvement on light interception and shading to hasten the closure canopy prior the cover crop rolling, combining rye with triticale characterized by wider leaves and shorter height than rye. Although a multispecies cover crop is more difficult to terminate by rolling, mixing rye to another cereal grain represents a viable solution as compared with pure rye in regions where the access to rye is lower or to face soil heterogeneity.

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Image:

Figure 1: Cover crop rolling and soybean planting - Isère, France, 2018 (Picture: L. Vincent-Caboud)

Image 2:

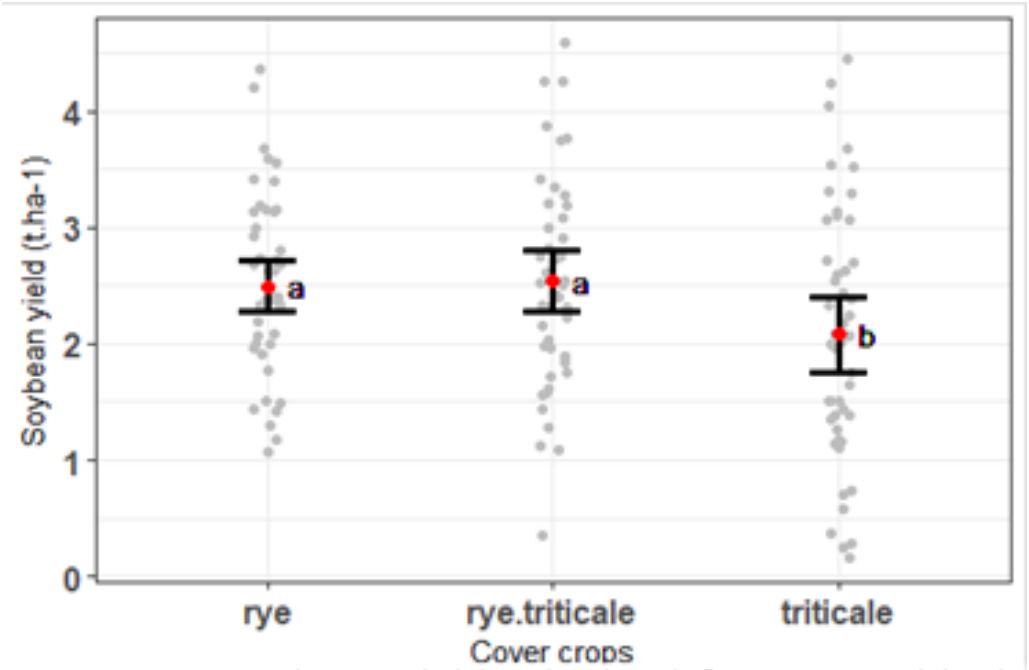

Figure 1: Soybean yields obtained from rye, triticale and rye/triticale cover crops treatments, averaged across all sites, analyzed using linear mixed model ($P < 0.001$, n=72). Cover crops followed by same letter are not significantly different.

Disclosure of Interest: None Declared

Keywords: direct seeding, mulch, organic soybean, roller crimper, weed control