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Session 4 - . Agricultural models for impact mitigation

Oral communications

Posters

Maize growth and yield responses to conservative tillage system and starter fertilization strategies

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Introduction

Maize (*Zea mays* L.) cultivation requires agronomic practices that maximize the farmer's net return and minimize the negative impacts on the agro-ecosystem. Conservation tillage can decrease cultivation costs compared to plowing, but it might decrease the grain yield due to a slower crop development in early stages (Morris *et al*., 2010). The starter fertilization at maize sowing is commonly used to improve early-season nutrient uptake, nutrient use efficiency and plant growth (Quinn *et al*., 2020). In this context, animal manures are important sources of nutrients that should be used efficiently to replace manufactured fertilizer. The aims of this study were to assess the effects of the first year adoption of conservative tillage system and different starter fertilization strategies, including digestate, on maize growth and yield.

Materials and Methods

The study was carried out during the 2019 and 2020 growing seasons through field experiments at two sites in Piemonte, NW Italy, i) Carmagnola: loamy silt soil (sand 36% and clay 7%) with medium Olsen P (14-21 mg kg^{-1}); and ii) Poirino: loamy silt soil (sand 26% and clay 13%) with medium (2019) or high (2020) soil Olsen P concentration (18-58 mg kg^{-1}). Different soil tillage techniques and starter fertilizations were compared at each site, according to a factorial combination within a split-plot design with four replications. The two considered tillage systems were:

- PLOW, where the soil was ploughed at 30 cm depth, then disk harrowed and rotary tiller levelled; this represents the common practice in the North of Italy;
- ST (strip-tillage), performed with specialized equipment set to a depth of 25 cm on 25 cm-wide strips and 50 cm-wide non-tilled strips with standing maize residues.

Two different placements of starter fertilizers were compared to an untreated control (NT):

- DAP (diammonium phosphate, 18-46% for N and P_2O_5, respectively *w/w*) distributed in 5 cm-deep bands on the side of the rows of maize seeds, supplying 27 kg N ha^{-1} and 69 kg P_2O_5 ha^{-1};
- SLU (digestate, 6.7-2.4% for N and P_2O_5 respectively *w/w* dry matter basis) injected as a 20 cm-deep band by a slurry tank equipped with injector tools, concurrently to the ST operation or after the rotary harrowing in PLOW, supplying 202 kg N ha^{-1} and 69 kg P_2O_5 ha^{-1}.

Top-dressing N applied as Urea (46% N *w/w*) was used to equal the N supply in the two fertilized treatments, with differences between the two sites to take account of a different soil fertility and local standards to achieve the full potential grain yield. The NT treatment received no P, and top-dressed N only, at the same amount as the DAP treatment.

The normalized difference vegetation index (NDVI) was measured weekly from the 3-leaf stage to the tassel emission using the GreenSeekerTM® device. The anthesis was determined when >50% of the plants in the plot had stigmata tips visible and expressed as days after sowing (DAS). At maturity grain yield and grain moisture were recorded. Data were analyzed through a mixed ANOVA model, where site, tillage system and starter fertilization were considered as fixed factors, while year and maize hybrids as random effects and the means were compared using the Bonferroni post hoc test at the $P \leq 0.05$.

Results

The maize canopy development assessed with the NDVI was influenced by the adopted tillage system as well as by the starter fertilization (Figure 1). The ST technique determined the coolest soil conditions at both experimental sites, resulting into lower NDVI values due to a lower plant growing rate and crop density. The DAP starter fertilization showed the highest early vigor and canopy development in both sites and tillage systems, while generally, while SLU values were intermediate between DAP and NT.

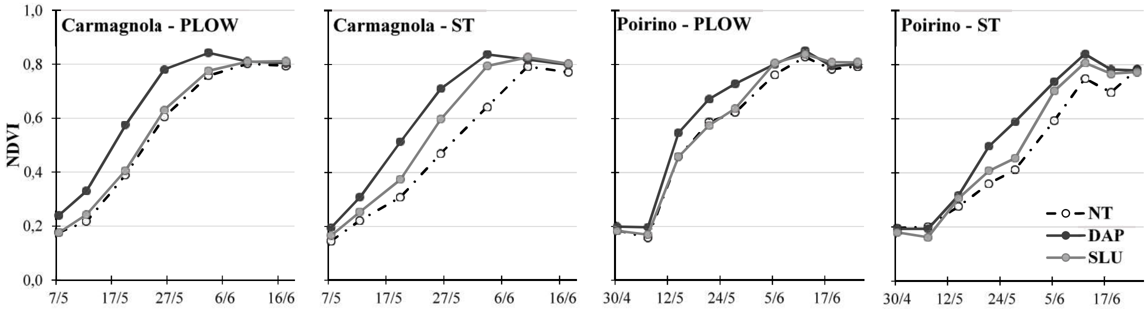

Figure 1. Effect of starter fertilization within each site-tillage system combination on the maize canopy development expressed as NDVI from three-leaf stage to tasseling during the 2020 growing season.

The higher maize development (e.g. higher plant height and leaf area index) quantified through the NDVI due to plowing or the starter fertilization was confirmed at flowering and at harvest. Compared to ST, the PLOW treatment anticipated the flowering of 2.2 days, and reduced the grain moisture content of 1.2 percentage points (Table 1). The anticipation of flowering was greater at Poirino (-3.4 days) compared to Carmagnola (-1.1 days). Similarly, DAP treatment lowered the grain moisture content by 0.8% compared to the SLU treatment, that resulted drier by 1.1% than NT. For both tillage systems, at Carmagnola SLU and NT treatments showed similar grain moisture contents, while at Poirino the SLU treatment did not differ from the DAP treatment. The grain yield was not affected by the tillage system, while DAP and SLU recorded similar and higher (+1.6, +1.8 t ha^{-1}) grain yield than the NT treatment.

Table 1. Effect of site, tillage and starter fertilization on maize date of flowering expressed as days after sowing (DAS), grain moisture content and grain yield.

Factor	Source of Variation	Flowering (DAS)	Grain moisture (%)	Grain Yield (t ha^{-1})
Site	Carmagnola	87.5 b	24.4 b	16.4 a
	Poirino	101.7 a	25.6 a	15.5 b
	p(F)	< 0.001	< 0.001	0.013
Tillage	PLOW	93.5 b	24.4 b	15.9
	ST	95.7 a	25.6 a	15.9
	p(F)	< 0.001	< 0.001	n.s.
Starter fertilization	NT	97.0 a	26.0 a	14.8 b
	SLU	94.4 b	24.9 b	16.6 a
	DAP	92.4 c	24.1 c	16.4 a
	p(F)	< 0.001	< 0.001	< 0.001
Site x Tillage	*p*(F)	< 0.001	< 0.001	< 0.001
Site x Starter	*p*(F)	n.s.	n.s.	n.s.
Tillage x Starter	*p*(F)	n.s.	n.s.	n.s.
Site x Till. x Starter	*p*(F)	n.s.	0.027	n.s.

Conclusions

This study highlighted that ST was a suitable technique in different pedo-climatic conditions, without any yield reduction. The deep injection of digestate as a starter fertilizer showed moderate advantages on maize early development, and allowed to achieve the same yield as the mineral starter fertilization.

Literature

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