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Soil Olsen P And Maize Crop Responses To Phosphorus Starter Fertilisation

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Introduction

Low phosphorus (P) solubility limits its concentration in soil solution and crops may acquire insufficient P, resulting in retarded growth and, in maize, the typical purpling of leaves (Plénet et al., 2000). Farmers localise mineral P at sowing to stimulate the early plant growth, hovewer the use of mineral P is questionable where animal manures are distributed at rates sufficient to meet the annual P crop needs and/or the soil P status is high (Schröder et al., 2015).

The objectives of this work were to test the crop response to starter P fertilisation in a soil at different enrichment levels due to long-term (LT) fertilisation using mineral fertilisers or manures, and to derive a crop response curve to soil available P.

Materials and Methods

A field experiment was carried out in NW Italy during the 2019 and 2020 growing seasons on selected plots of the LT experiment of Tetto Frati (44°53'N; 7°41'E; 232 m a.s.l.) of the University of Turin. The trial compared sub-surface placement of NP (as diammonium phosphate; 27 kg N ha^{-1} and 69 kg P_2O_5 ha^{-1}) or N alone (ammonium nitrate; 27 kg N ha^{-1}) at sowing, in bands close to the maize seed furrows, in differing long-term (LT) fertilisation managements: two doses of urea (Min-L and Min-H), two doses of bovine slurry (Slu-L and Slu-H) or two doses of farmyard manure (Fym-L and Fym-H). The two rates, low (L) and high (H), corresponded to 170 and 250 kg N ha^{-1} $year^{-1}$ respectively, in all fertilisation systems. At the start of the experiment, the six systems had different soil P contents, since they were the result of LT fertilisation managements. The soil Olsen P concentrations before the experiment start showed the highest value in Fym-H (91 mg kg^{-1}), followed by Fym-L (52 mg kg^{-1}), the lowest values in both Min treatments (c. 14 mg kg^{-1}), and intermediate values in Slu (c. 29 mg kg^{-1} of Olsen P).

In both years, the crop development was assessed through different parameters (crop height, biomass, NDVI, Leaf Area Index, date of flowering). At maturity, maize grain yield, humidity, mycotoxin content and plant total P uptake were assessed. The soil was sampled at 50 days after sowing (DAS). Three 0-30 cm deep soil cores were collected with an auger along the central rows of each plot and pooled together to obtain a representative sample for the plant-available P determination, using the Olsen method. A linear-plateau model was used to interpolate soil Olsen P vs the true soil available P for the crop, as assessed by the plant uptake at harvest.

Results

Compared to the N only treatment, the starter NP fertilisation at sowing did stimulate the plant growth in early stages. Differences were more pronounced in the mineral systems than in the manured systems, and were more evident in the cooler year, 2019. However, differences in crop growth between NP and N starter fertilisations levelled up at the flowering stage (that occurred 1 day sooner in NP treatments, on average) and were detectable at harvest as yield, grain humidity or sanitary traits only in Min systems, but not in Slu or Man systems (data not shown; Battisti et al., 2022).

The P starter fertilisation influenced the available P as assessed by soil analysis during the early growth phases of maize growth, in interaction with the LT fertilisation. The soil Olsen P concentration at 50

DAS was consistently increased in the NP treatment compared to N, in Min-H e Slu-H treatments, while this trend was observed in Min-L and Slu-L in only one of the experimental years (Table 1). Conversely, when LT fertilisation included farmyard manure, no significant differences were found in soil Olsen P concentration as a consequence of NP starter fertilisation compared to N.
The total plant P uptake at harvest, that represents a true indicator of soil P availability, showed a linear-plateau response to soil Olsen P measured near roots at 50 DAS (Figure 1). The plant P uptake increased linearly up to the threshold of 39 mg P kg^{-1} of Olsen P, then stabilised, as luxury consumption of P is not typical in maize.

Table 3. Effect of starter fertilisation on soil Olsen P. Asterisks denote significant differences (* p <0.05; ** p <0.01; *** p <0.001) between means in long-term fertilisation × starter fertilisation × year interaction (p= 0.010), separated through a Bonferroni post hoc test.

P Olsen (mg kg^{-1})		N	NP	Sig. p
2019	Min-L	9.3	15.9	*
	Min-H	6.4	27.6	***
	Slu-L	27.4	30.1	
	Slu-H	26.5	37.6	**
	Fym-L	50.8	61.4	
	Fym-H	74.7	77.5	
2020	Min-L	8.8	13.9	
	Min-H	6.7	14.6	*
	Slu-L	25.8	37.8	**
	Slu-H	23.1	35.1	***
	Fym-L	46.6	50.4	
	Fym-H	80.1	82.0	

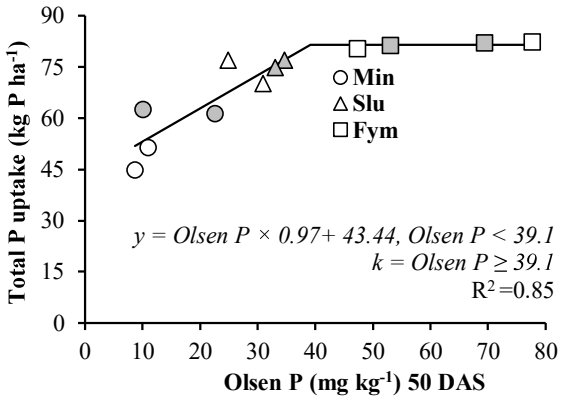

Figure 10. Total above-ground plant P uptake at harvest vs soil Olsen P concentration at 50 Days After Sowing, averaged over the two years (n=6). Open symbols = N starter fertilisation, closed symbols = NP starter fertilisation.

Conclusions

The starter NP fertilisation at sowing did not affect maize yield, grain humidity or sanitary traits, although an initial stimulation of plant growth was observed in P medium-enriched soils. Consequently, the starter NP fertilisation at sowing is recommended in soils with a low available P content, and should be avoided in rich soils, such as the ones that received farmyard manure. The situations where slurry was supplied, that had a soil P content that was considered high (20-30 mg kg^{-1} of Olsen P) were intermediate, and the benefit of starter NP fertilisation on crop growth depends on weather conditions, and in particular on temperature. In the framework of a changing climate, starter fertilisation could help ensuring high yields in unfourable conditions. In additions, thresholds above which a suspension of P fertilisation is recommended should be revised, as the maize plant P uptake was reduced below 39 mg kg^{-1} of Olsen P, which is far above the thresholds normally used to decide about fertilisation suspension.

Literature

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