

Comparative effects of MPR and P water soluble fertilisers on maize yield in sandy soils of Tabora, Tanzania

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Abstract

An on-station experiment was conducted at ARI –Tumbi, Tabora, Tanzania during 2010/ 2011 cropping season to compare the effects of Minjingu Phosphate Rock (MPR) with various water soluble P fertilisers on maize response in sandy soils. Water soluble fertilisers used in the experiment were Di-ammonium phosphate (DAP) at 30 and 15 kg P /ha, and NPK 10-18-24 at 30 kg P /ha. Water insoluble MPR in powder and granule forms was applied at 30 kg P /ha. The experiment layout was a Complete Randomized Block Design (RCBD), with a P control treatment applied with 100 kg N/ha, which was the same rate applied to all P treated treatments. The maize mean yields were 2836, 3688, 3839, 3988, 4014, 4612 (kg/ ha) for control, DAP 15, DAP 30KG, MPR granules, MPR powder, and NPK treatments, respectively. Control treatment had the lowest yield which was significantly different ($p= 0.005$) with the P treated treatments. There were no significant differences in maize mean yields when MPR treatments were compared with DAP and NPK treatments at 30 P kg/ ha. This implies that the fertilization of maize with MPR can replace the NPK and DAP fertilisers provided that N and other necessary nutrients are applied. Maize mean yields in MPR powder treatment was relatively higher to MPR granules treatment, but the difference was not significant ($p= 0.05$) implying that both granules and powder forms can be recommended to be used by farmers, but farmers applying powder form can increase their yields. The highest yield attained in NPK treatment might be contributed by the presence of K in fertiliser because soil analysis showed the nutrient level was low.

Key words: Acidic sandy soils, Minjingu phosphate rock (MPR), water soluble fertilisers

Résumé

Une expérience en station a été réalisée à ARI-Tumbi, Tabora, en Tanzanie au cours de la campagne agricole de 2010/2011 afin de comparer les effets de la roche phosphatée de Minjingu (MPR) avec des engrais phosphatés solubles dans l'eau sur la

réponse du maïs dans les sols sableux. Les engrais solubles dans l'eau utilisés dans l'expérience étaient le Di-ammonium phosphate (DAP) à 30 et 15 kg de P / ha, et le NPK 18-10-24 à 30 kg de P / ha. La roche MPR insoluble dans l'eau en poudre et sous forme des granules a été appliquée à 30 kg de P / ha. Le dispositif expérimental était une conception en bloc aléatoire complet (RCBD), avec un traitement de contrôle de P appliqué avec 100 kg de N / ha, ce qui était le même taux appliqué à tous les traitements de P réalisés. Les rendements moyens du maïs étaient 2836, 3688, 3839, 3988, 4014, 4612 (kg / ha) pour le contrôle, DAP 15, DAP 30KG, MPR granulés, MPR en poudre, et les traitements NPK, respectivement. Le traitement témoin avait le plus faible rendement qui était significativement différent ($p = 0,005$) des traitements de P réalisés. Il n'y avait pas de différences significatives dans les rendements moyens du maïs lorsque les traitements de MPR ont été comparés aux traitements NPK et DAP et à 30 kg de P / ha. Cela implique que la fertilisation du maïs avec MPR peut remplacer les engrais NPK et DAP à condition que N et autres nutriments nécessaires soient appliqués. Le rendement moyen du maïs dans le traitement de MPR en poudre était relativement plus élevé à celui du traitement de MPR sous forme de granules, mais la différence n'était pas significative ($p = 0,05$) ce qui implique que les deux formes en poudre et en granules peuvent être recommandées pour être utilisées par les agriculteurs, mais les agriculteurs appliquant la forme en poudre peuvent augmenter leurs rendements. Le rendement le plus élevé atteint dans le traitement NPK pourrait être apporté par la présence de K dans l'engrais car l'analyse du sol a montré que la teneur en nutriments était faible.

Mots clés: Sols sableux acides, Roche phosphatée de Minjingu (MPR), engrais solubles dans l'eau

Background

The dominant soils in Tabora, Tanzania are sandy, acidic, with low cation exchange capacity, with low available phosphorus (P) to the growing plants (Kwesiga *et al.*, 1999). To grow good crops in these soils farmers have to use various P sources, commonly, water soluble phosphatic fertilisers. These fertilisers are expensive to poor resource farmers and the alternative is the cheap water insoluble Minjingu phosphate rock (MPR). However, few farmers producing maize have reported good results of MPR effectiveness especially during the first season of application. Different MPR forms are available in granule

and powder for farmers' use mainly supplying P and Calcium (Msola *et al.*, 2005).

Literature Summary

The effectiveness of MPR is erratic with varied responses in different parts of the country especially during the first year/season of application mainly due to slow dissolution. The dissolution of PR in the soil solution is affected by a combination of factors, some of which include texture, moisture, pH of the soil, Ca levels, within field variability (Mowo, 2000).

Study Description

This study was conducted at ARI- Tumbi Research farm, Tabora in the western zone of Tanzania. The region has unimodal type of rainfall, and during the experiment only 569 mm rainfall was obtained. Two forms of MPR namely powder and granules were applied, both of them contain organic hyper-phosphate with (29 % P_2O_5 , and 38 % CaO). The performance of these fertiliser forms were compared with DAP, and NPK 10 18 24. Urea was applied to maintain Nitrogen at 100 kg / ha for all the treatments. Another was P treatment control where only N was applied at various stage of development as was applied in the P treatments. By 25 days all the treatments were applied with 60 % of Nitrogen. The rest 40 % N was applied near to maize tasseling. The trial was laid out in a randomized completely block design (RCBD) with three replications. The treatments in the experiment were as follows: MPR powder 30 kg P/ha, MPR granules 30 kg P/ha, NPK 10 18 24, 30 kg P/ha, DAP 15 kg P /ha, DAP 30 kg P /ha and absolute control – no P applied treatment. Except for the absolute control treatment all the plots were applied with each type of phosphatic fertiliser as basal application at sowing time and maize was planted in all plots on the same day. The test crop was maize, variety *Kilima* planted at a spacing of 90 cm by 50 cm with two plants per hill (equal to 44,444 plants/ha). Before land preparation the uncultivated soil for three years was sampled at 0–30 cm layer to quantify initial status of soil under study; similarly soil sampling was done during maize harvesting. Three soil samples were collected in each replication to make a bulk. The bulks of soil from replications of each respective treatment were bulked again to make soil composite. Half kilogram of soil from each composite of treatment was taken for laboratory analysis. The soil samples were analyzed for organic carbon, total nitrogen, pH (1:1.25 H_2O), available P, exchangeable K, Ca, Mg, Na and Ec (Soil National Service of 1987). Soil properties and maize yield were the major data collected. The variables collected

were analyzed using MSTAC and the means were separated by Duncan Multiple Range Test (DMRT).

Research Application

Soil pH indicated that the soil under study was favorable for MPR dissolution because it could supply appreciable hydrogen ions to neutralize the hydroxyl ions released during the dissolution process. Also the level of available P was low (Table 1) not only for a good crop but also to facilitate MPR dissolution. It was reported by Szilas *et al.* (2007) that the highest response to MPR is obtained under both pH (< 6.0) and available P (< 10 mg/kg). According to Tisdale (1993) the values of exchangeable bases in Me/100g or cmol (+)/kg in this soil indicated low Ca, K and, Mg. To adopt a good fertilization regime these nutrients need to be included in fertilisers supplied to maize growers in the region.

The pH levels were decreased in all the treatments (Table 2). This might be acidifying effect of maize crop as cations are taken up and leave H ions to dominate. Also Urea may have had an acidifying effect as it may have released protons during nitrification process. MPR treatments had relatively higher pH than other fertiliser treatments. This might indicate that MPR had a tendency of increasing pH probably due to Ca release (Kosia, 2003). The soil available P (Bray I mg/kg) after maize harvest was relatively high in MPR powder compared to other treatments. This indicate that with the available moisture in soil MPR powder continued to release P in soil solution even after

Table 1. Soil characteristics before land preparation.

Treatment	pH (H ₂ O)	Total N (%)	P (Bray- I) mg/kg)	K ⁺ Me/ 100g	Ca ⁺ Me/ 100g	Mg ⁺ Me/ 100g	Na ⁺ Me/ 100g
Control	5.8	0.03	3.15	0.2	1.63	0.06	0.24

Table 2. Characteristics of soil after MPR and other fertiliser application during harvesting time.

Treatment	pH (H ₂ O)	Total N (%)	Bray I - P (mg/kg)	OC (%)	K ⁺ me/ 100g	Ca ⁺ me/ 100g	Mg ⁺ me/ 100g	Na ⁺ me/ 100g	EC (ms/cm)
Control	5.0	1.63	2.89	0.43	0.14	1.41	0.05	0.19	0.04
DAP 15 kg	5.1	1..9	3..04	0.36	0.16	0.84	0.04	0.19	0.04
DAP 30 kg	5..2	2..29	3..23	0.54	0.16	1..54	0.06	0.21	0.06
MPR granules	5..5	0.02	4..25	0.41	0.15	1.62	0.04	0.21	0.04
MPR powder	5..5	0.03	8.16	0.53	0.17	2.16	0.05	0.22	0.05
NPK	5..3	2.07	4..34	0.54	0.47	1.58	0.05	0.21	0.11

Table 3. Means of maize yields after harvesting.

Treatments	Yield in kg/ ha
Control	2836 c
DAP 15 kg	3688 ab
DAP 30 kg	3839 a
MPR granules	3988 a
MPR powder	4014 a
NPK	4612 a
Coefficient of variation	11.32%
LSD	910.2

Means in the same column followed by the same letter(s) are not significantly ($P=0.05$) different according to the Duncan New Multiple Range Test (DNMRT).

plant uptake stopped. The yields of maize ranged from 2836 to 4612 kg/ha (Table 3). These yields are above the mean average national maize yield of 1.2 t/ha showing that fertiliser application is necessary in these soils. The yield of treated maize with only Nitrogen (Control treatment) was significantly low ($P = 0.05$) compared to those treated with P fertilisers. This implies that application of only N fertilization to maize limits the production potential of the maize varieties; also P is very important to maize production in sandy soils of Tabora. When P was applied at 30 P kg/ ha there were no significant differences in maize yields on MPR treatments compared to DAP and NPK treatments. This implies that the fertilization of maize with MPR in these soils can be an alternative to NPK and DAP fertilisers provided that N is timely applied. This may indicate that sandy soils of Tabora favor dissolution of MPR to release P for maize plant growth. The NPK fertiliser gave relatively higher yields although not significant compared to other P fertilisers applied at 30 kg P/ha. This is because the contribution of K as the essential nutrient was very important taking into consideration that K in soil was low at planting time (Table 1). Maize yields in MPR powder treatment was relatively higher to MPR granules, but the difference was not significant ($p= 0.05$). This implies that both granules and powder forms can be used by farmers, though farmers applying powder form can increase some yields. This is because the surface area of powder form is higher hence increased available P and uptakes to plants as compared to granules. Due to insignificance in yields farmers with low labor for farming might be recommended to use granules as the fertiliser is easier to apply. PRs are relatively insoluble materials; their particle size has an important bearing

on their rate of dissolution in soil and interception to root hairs. The DAP 15 kg P/ ha treatment yielded low indicating the amount of P applied could not suffice the plant requirement. Therefore farmers applying less than 30 P kg / ha in these sandy soils might be producing less yields.

Because MPR is cheap then its use can be an alternative for water soluble fertilisers in the sandy soils of Tabora provided that other nutrients in addition to P should be considered; inclusion of MPR with starter N is thus very important. The best practices in this study should be repeated in on-farm trials.

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