Research Application Summary

Effectiveness of white lupin (*Lupinus albus*) and chickpea (*Cicer arietinum*) in enhancing phosphorus release from rock phosphate

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Abstract

Smallholder farming systems are characterised by application of suboptimal rates or non utilisation of inorganic fertilisers due to their exorbitant prices vis-à-vis low financial return from crops. Minjingu rock phosphate (MPR) would be a viable option to the expensive inorganic phosphorus (P) fertilisers but is insoluble. The use of white lupin and chickpea, apart from fixing N, can enhance the solubility of rock phosphate through the release of carboxylic acids. The objective of the study is to increase P release from MPR and soil available N content using white lupin (*Lupinus albus* L. cv. Amiga) and chickpea (*Cicer arietinum* L). The study will be carried out at Egerton University Research Field (Field 7) and University of Nairobi Kabete Farm. The experimental design will be a randomised complete block design with a split plot arrangement. The main treatment will be cropping system (monocropping, intercropping and crop rotation) while sub-plot treatments P source (TSP and MPR). Maize and sorghum will be the test crops. Green house experiments with varying rates of MPR (0, 30, 60, 60 kg P ha^{-1}) under lupin or chickpea will also be established. P and N contents in soil and plant tissues will be measured at different growth stages. Additionally, P and N balances in soil, pH and organic C will be measured. It is hypothesized that growth of white lupin and chickpea in rotation or as an intercrop with the application of MPR will lead to increased soil available P and N with resultant high maize and sorghum yields.

Key words**:** Cropping systems, maize, minjingu phosphate rock, sorghum, solubilisation

Résumé

Les petites exploitations agricoles sont caractérisées par l'application des taux sous-optimaux ou la non-utilisation des engrais inorganiques en raison de leurs prix exorbitants vis-à-vis de faible rendement financier des cultures. Le phosphate de roche de Minjingu (MPR) serait une option viable pour les engrais chers contenant le phosphore inorganique (P), tout en étant insoluble. L'utilisation du lupin blanc et de pois chiches, à l'exception de la fixation de N, peut améliorer la solubilité du phosphate de roche par la libération d'acides carboxyliques. L'objectif de l'étude est d'augmenter la libération de P de MPR et la teneur en azote disponible dans le sol en utilisant le lupin blanc (*Lupinus albus L. cv. Amiga*) et le pois chiche (*Cicer arietinum L*). L'étude sera menée sur le terrain de recherche de l'Université Egerton (Terrain 7) et la ferme de Kabete à l'Université de Nairobi. Le montage expérimental sera un dispositif aléatoire en blocs entiers avec un arrangement de parcelles divisées. Le traitement principal sera le système de culture (monoculture, les cultures intercalaires et la rotation des cultures), tandis que les traitements des sous-parcelles seront la source de Phosphore (TSP et MPR). Le maïs et le sorgho seront les cultures d'essai. Les expériences dans la serre à des taux variés de MPR (0, 30, 60, 60 kg P ha-1) sous le lupin ou le pois chiche seront également établies. Les teneurs en P et N dans les sols et dans les tissus des plantes seront mesurées à différents stades de croissance. En outre, les proportions de P et N dans le sol, le pH et le carbone organique C seront mesurées. L'hypothèse est que la croissance du lupin blanc et des pois chiches en rotation ou en culture intercalaire avec l'application de MPR mènera à l'accroissement de P et N disponible dans le sol avec comme résultat des hauts rendements en maïs et sorgho.

Mots clés: Systèmes de culture, maïs, roche phosphatée Minjingu, sorgho, solubilisation

Background

In Kenya, maize (*Zea mays*) and sorghum (*Sorghum vulgare*) are important crops mainly grown by smallholder farmers. Per capita consumption for maize in Kenya is 103 kg yr^{-1} (Pingali, 2001). Production of these crops must increase if the be met (KARI/MIAC, 1993). Just as in other East African crops (FAO, 2004), production of these crops in Kenya is constrained by low soil phosphorus (P), which is the second most critical plant nutrient after nitrogen (N). In Kenya, smallholder farming systems are characterised by use of sub-optimal rates of inorganic fertiliser doses due to their exorbitant prices vis-à-vis low financial return from crops (Henao and Baanante, 2001). This has resulted in declined crop yields leading to unsustainable crop production. Minjingu rock phosphate (MRP) is envisaged to be a viable option to the expensive inorganic P fertilisers. However, its use in soil fertility improvement is limited by its being insoluble. It is envisioned that white lupin and chickpea can enhance soil fertility by mobilising P from MRP and increasing soil available N through biological N fixation. Chickpea (*Cicer arietinum* L.) and lupin (*Lupinus albus L. cv. Amiga*) exude carboxylates from their roots that are reported to have capacity to solubilise rock phosphate (Veneklaas *et al*., 2003; Gerke *et al*., 2000). The direct application of phosphate rock along with planting of the legumes lupin and chickpea is envisaged to enhance soil N and P and thereby provide a sustainable approach of enhancing maize and sorghum yields. The effectiveness of lupin and chickpea on the release of P from MRP and subsequent availability of N to sorghum and maize will be evaluated in this study.

Literature Summary

Maize (*Zea mays* L.) and sorghum (*Sorghum vulgare*) are important food crops in Kenya. After N, P is the second most frequently limiting macronutrient for maize and sorghum growth. About 80% of African soils have inadequate amounts of these critical nutrient elements. The supply of P to crops can only be increased from inputs such as manures, rock phosphate or mineral fertilisers. Smallholder farming systems are characterised by non-use use or use of suboptimal rates of inorganic fertilisers (Henao and Baanante, 2001). This situation has generated considerable interest towards direct utilisation of rock phosphate (Besharati *et al*., 2001). Indigenous technologies such as the use of rock phosphate can be substituted for imported refined sources. Minjingu rock phosphate (MRP) is indigenous to Tanzania (Rweyemamu, 1990). Its direct application may be an alternative to the use of more expensive soluble phosphorous. MRP is however insoluble. Chickpea (*Cicer arietinum* L.) and lupin **(***Lupinus albus L. cv. Amiga*) are reported to exude carboxylates from their roots (Veneklaas *et al*., 2003) that can enhance the solubility of rock phosphate.

Study Description

The study will be conducted at the Egerton University Research Field and Kabete Farm, University of Nairobi for four seasons. The experimental design will be a randomised complete block (RCBD) in a split plot arrangement. The main plot treatment will be cropping system (i.e., cereal monocrop, a legume - cereal rotation and a legume/cereal intercrop). The cereals will be sorghum and maize and the legumes lupin and chickpea. The subplots will be two P sources; TSP and MPR applied at the rate of 60 kg ha^{-1}. Field trials will be supplemented with greenhouse experiments in which the effect of varying application rates of MPR (O, 30, 60, 60 kg P ha^{-1}) with lupin and chickpea will be evaluated. Soil and plant samples will be collected at seedling, tasseling and maturity stages of sorghum and maize and monitored for N and P nutrient levels. The P and N balances in soil and organic C will also be measured.

Expected Output

The relative effectiveness of lupin and chickpea in solubilising MRP will be established. The study will also allow us to determine the extent to soil fertility can be improved by application of MRP using sorghum and maize as case studies.

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