Second RUFORUM Biennial Meeting 20 - 24 September 2010, Entebbe, Uganda

Research Application Summary

Strategy for improving bush bean production on a phosphorus fixing Andosol with aquic moisture regime

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Abstract

In Uganda, bean is a food security and income sourcing crop, particularly for the rural poor. The highlands of southwestern Uganda are major producers and consumers of the crop. The arable soils in the highlands bordering Rwanda and DR Congo are mostly volcanic ash based, typically known to fix phosphorus but the extent to which this occurs (sorption-desorption phenomena) remains unknown. Moreover, the soils are increasingly affected by waterlogging to levels that impair bean growth and yield. Therefore, the study objectives were to identify farmer coping mechanisms for bush bean production under waterlogging conditions, and determine the optimum application rates of phosphorus for bush bean production on an acid Andosol. Preliminary results indicate that due to water logging effects of P on bean growth was not apparent. Because of water logging, growing bush beans is being abandoned in favour of climbing beans.

Key words: Bean production, food security, sorption-desorption phenomena, volcanic ash, waterlogging

Résumé

En Ouganda, le haricot est une culture source de revenu et de sécurité alimentaire, en particulier pour les pauvres ruraux. Les montagnes de l'Ouganda du sud-ouest sont les producteurs et les consommateurs principaux de la récolte. Les sols arables dans les montagnes environnantes du Rwanda et de la RD Congo sont la plupart du temps cendre volcanique basée, typiquement connues pour fixer le phosphore mais l'ampleur à laquelle ceci se produit (phénomènes d'absorption-rejet) reste inconnue. D'ailleurs, les sols sont de plus en plus affectés par l'envahissement par l'eau aux niveaux qui altèrent la croissance et le rendement de haricot. Par conséquent, les objectifs de l'étude étaient d'identifier les mécanismes de faire face de l'agriculteur pour la production de haricot de buisson dans des conditions d'envahissement par l'eau et de déterminer les taux optima d'application de phosphore pour la production de haricot de buisson sur un Andosol acide. Les résultats préliminaires

indiquent qu'en raison des effets d'envahissement de l'eau de P sur la croissance de haricot n'était pas évident. En raison de l'envahissement de l'eau, le haricot croissant de buisson est abandonné en faveur de haricot rampant.

Mots clés: Production de haricot, sécurité alimentaire, phénomènes d'absorption-rejet, cendre volcanique, envahissement par l'eau

Background

East Africa is among the regions experiencing unprecedented levels of food insecurity and abject poverty in Sub-Saharan Africa (SSA). This is largely due to diminishing productivity of agricultural resources, against a surging human population characterized by growth rates ranking the highest in the world. Phosphorus deficiency is among the renowned abiotic stresses particularly in common bean (*Phaseolus vulgaris* L.) in SSA. In this region common bean is the primary source of protein for the majority of the people (Beebe *et al*., 2010).

In Uganda, bean is a food security and income sourcing crop, particularly for the rural poor. The highlands of southwestern Uganda are the major producers and consumers of the crop. The arable soils in the highlands bordering Rwanda and DR Congo are mostly volcanic ash based, typically known to fix phosphorus but the extent to which this occurs (sorption-desorption phenomena) remains unknown. Moreover, the soils are increasingly affected by waterlogging (aquic moisture regime) to levels that impair bean growth and yield. There is need for documentation of the coping mechanisms available to farmers under these unfavourable circumstances in order to enhance bean production in the region.

Literature Summary

Phosphorus is one of the most limiting nutrients seriously affecting crop production in Eastern Africa. This is so because of the widespread presence of sesquioxides which possess huge capacities of phosphorus (P) fixation (Smithson and Giller, 2002). However, although volcanic ash based soils are also present in the region, there is hardly any information related to P dynamics in the soil, yet literature from elsewhere suggest that such soils are heavy fixers of P (Nanzyo, 2002). At the same time it is reported that the P fixation capacity of the soil depends on several factors including clay mineralogy, level of organic matter, pH, exchangeable aluminium and iron, among other things (Ibia *et al.*, 2009). Therefore, P fixation capacity varies greatly among sites.

Another constraint to agriculture and crop production in complex ways is waterlogging. When a soil becomes waterlogged, the air in the pore spaces of the soil is replaced with water, greatly restricting the flow of oxygen through the soil. The small amount of oxygen left in the soil is quickly depleted by root and soil microorganisms' respiration (Riche, 2004). In these conditions, adverse effects on plants occur such as chlorosis, reduced growth rate, disruption of cell membranes, adverse effects on mineral uptake, altered growth regulator relationships, stomatal closure, leaf wilting and epinasty, reduced photosynthesis and respiration, altered carbohydrate partitioning, and potentially death (Steffens *et al.*, 2005).

Common bean especially bush bean varieties is among sensitive crops to excessive soil moisture. A number of studies report the negative effects of waterlogging on various growth parameters of legume crops. In a waterlogging simulated experiment, Stewart *et al*. (2005) determined the effects of various durations of flooding on bush bean at different growth stages. They found that after five or more days of flooding there was more than a 50% reduction in photosynthesis, leaf area and dry weight. Where flooding was imposed before flowering, yield reduction was attributed to low plant survival and fewer pods per plant. If flooding begins after flowering, then yield reduction is due to a lower pod weight. Leaf senescence coupled with reduced CO_2 assimilation in the remaining leaves, likely inhibited the plants ability to allocate photosynthate to the developing pods. Similar effects of waterlogging have also been noted in other legumes such as soy bean, where flooding for as little as 3 days at the early vegetative growth stages killed the plant (Boru *et al.*, 2003**).**

Study Description

The study was conducted in Chahi Sub-county, Kisoro district of south western Uganda. A survey was conducted using a questionnaire on ninety households. This was to explore farmer perceptions regarding bush bean production under the influence of waterlogging and identify coping mechanisms used. In addition to the survey, an on-farm experiment was conducted with P rates of 0, 10, 20, 30 and 40 kg ha^{-1} and lime as Ca $(OH)_2$ at 0, 1, 1.5 and 2 t ha^{-1}, laid out factorially in a randomized complete block design (RCBD). The test crop was bush bean variety NABE 14. A greenhouse experiment was also conducted using the same treatments and experimental design, as a guard against field weather uncertainties. Furthermore, laboratory studies were conducted to evaluate the P sorption-

desorption phenomena in order to establish the chemical bases for phosphorus availability. The survey entries were analyzed and the interpretation process is underway. Nevertheless, it can be inferred from emerging trends that bush bean is slowly being abandoned by farmers due increased waterlogging periods, despite the great value attached to them. Climbing bean is increasingly the alternative to bush bean except in cases where constraints associated with climbing bean become overwhelming. The first season of the field experiment was devastated by excessive waterlogging but second season crop performed fairly better. The greenhouse study has been repeated 3 times and the data will be useful in supporting field data. The process of charactering P sorption-desorption is underway, however, sorption requires minimum 24 hours shaking, while desorption requires 2 hours shaking repeated more than 25 times.

Findings

The field experiment was largely waterlogged (H" 65 % moisture content) and this affected performance of the bean plants. It is imperative that coping mechanisms for bean production under the circumstance be identified or developed. Indeed the survey is due to be undertaken to establish the farmer coping mechanisms as a plateform for scientific interventions. Furthermore, the effects of P application on bean growth and yield was not obvious, possibly because of the high P fixation capacity and the low rates of P applied. This was true despite the availability of literature that suggests that P availability in the soil under reducing condition is enhanced by the rise in pH. This appears to be rooted in the very low native P in the soil (pre-experimental available (4.1 mg P kg^{-1}). Sorption-desorption analysis has given evidence of high P fixation in the Andosols of Kisoro district, though laboratory tests are still underway. In fact it is now clear that the rates of P applied in the field were too low to influence plant performance.

Research Application

This study will result in the following outputs beneficial to communities of Kisoro district, including farmers, extension groups and researchers:

(a) Optimum application rate for P that result in high bush bean yield for the Andosols that dominate the district

(b) The phosphorus fixation and release capacity of the soil that forms the basis for rationalized P management

(c) A set of farmer coping mechanisms for bean production under waterlogged conditions which will provide a platform for developed improved strategies for production of the crops

(d) The publications/thesis will provide policy makers with information on the constraints on bush bean production in the region and suggested interventions.

Recommendation

Study activities are still underway, thus it is still premature to advance recommendations at this stage.

Acknowledgement

The authors thank SCARDA-ECA for financing the study as part of the MSc. thesis research of the first author. and material contributions to my masters studies. We also thank ROFORUM for facilitating the study process and the Institut des Sciences Agronomiques du Rwanda (ISAR) for granting permission to the first author to undertake MSc training at Makerere University.

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