

Research Application Summary

Adapting soybean varieties to soil fertility variability for increased productivity in smallholder systems of Uganda

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Abstract

Biophysical conditions; climate and soil types underpin the suitability for growing of different crops at larger scales such as the agroecological regions while at the lower scales, crop production is governed by soil fertility status and management. These factors together with and socio-economic environment (e.g. culture, markets, infrastructure etc.) create niches for production of a given crop. This research aims at identifying niches for sustainable production of soybean and will test the hypothesis that suitability of different soybean varieties differ between and within agroecological zones. The research will be conducted in the Southern and Eastern Lake Kyoga basin and Northern tall grasslands agroecological zones and will involve active farmer collaboration. Participatory variety selection will complement agronomic experimentation to identify best fitting soybean varieties within the agroecological zones. Appropriate soil fertility management practices necessary for high productivity of the soybean varieties will also be developed.

Key words: Socio-ecological niche, soybean

Résumé

Les conditions biophysiques, les types de climat et de sol sous-tendent l'aptitude à la croissance des différentes cultures à grande échelle telles que les régions agro-écologiques, tout en échelles inférieures, la production agricole est régi par le statut de la fertilité du sol et de gestion. Ces facteurs ensemble avec ceux de l'environnement socio-économique (par exemple la culture, les marchés, les infrastructures, etc.) de créer des niches pour la production d'une culture donnée. Cette recherche vise à identifier les niches de production durable de soja et de tester l'hypothèse selon laquelle des aptitudes de différentes variétés de soja diffèrent entre et au sein de zones agro-écologiques. La recherche sera menée dans le sud et l'est du bassin du lac Kyoga et au Nord de hautes zones des prairies agro-écologiques et nécessitera la collaboration active des agriculteurs. La sélection variétale participative viendra compléter

l'expérimentation agronomique pour identifier les meilleures variétés de soja qui s'inscrivent dans les zones agro-écologiques. Des pratiques appropriées de gestion de la fertilité des sols nécessaires à une productivité élevée des variétés de soja seront également développés.

Mots clés: Niche socio-écologiques, le soja

Background

Soyabean is an important income and food crop in Uganda. Its production has been increasing over the years and since 2006 accounts for 0.1% of the country's crop exports (MAAIF, 2008). The local demand of soyabean for supplementing protein in animal feed is increasing (as fish is getting scarce and expensive), and use in baby food supplements. The crop's potential to contribute to improvement of livelihoods of smallholder resource poor farmers is challenged by its low productivity in smallholder farmer's fields. Yields on farmer's fields are variable and often less than half the average of those obtained from on station (2–3.5 t ha⁻¹) (Tukamuhabwa *et al.*, 2006).

Soyabean improvement research over the last two decades in Uganda has mainly concentrated on developing high yielding varieties through hybridisation of newly introduced varieties from 1987 to early 1990s (MA&USAID/MFAD, 1988). The collapse of the varieties due to diseases (eg. bacterial pastule, soyabean rust) led to research prioritising disease resistance with high yields from 1990s to date (MAAIF, 1992; 2007). Those researches however, scarcely emphasised soil fertility management and active farmer collaboration (Tukamuhabwa *et al.*, 2006) and risks the wider spread of this important commercial crop with a potential to improve soil productivity in the low resource use farms. Smallholder sub-Saharan African farming systems are highly diverse and heterogeneous (Giller *et al.*, 2006) and targeting of crop production interventions to according heterogeneity in soil fertility and considering farmers preferences will lead to identification of best fitting technologies to specified socio-ecological niches (Ojiem *et al.*, 2006; Vanlauwe *et al.*, 2007). The approach has been demonstrated to increase resource use efficiencies (land, labour and applied nutrients) and affords specificity in development of management interventions for specific ecological problems (Tittonell *et al.*, 2007; Zingore *et al.*, 2007; Ebanyat, 2009).

Currently a large number of potential high yielding soyabean varieties exist but they have not been evaluated for

appropriateness to soil fertility levels and farmers preference (MAAIF, 2007).

Nitrogen and phosphorus are the major nutrients limiting crop production in smallholder farming systems in Uganda (Wortmann and Eledu, 1999). Soyabean can add nitrogen to the soil through N_2 -fixation and turn it over to subsequent crop hence increasing the systems productivity. In poor fertility soils, however, P additions and or starter N may be required for soyabean production but optimum quantities of these nutrients are not known for soil fertility niches for soyabean. Appropriate configuration of cropping systems with soyabean for higher total productivity and economic returns is paramount for scalability. Growing cereals after legumes contributes to higher yields of the cereals. Upland rice is an emerging economic crop promoted for improving rural household incomes but whose productivity is also limited by soil fertility. Participatory evaluation of soyabean varieties-upland rice systems under varying soil fertility niches will lead to identification of specific soil fertility niches and development of appropriate management practices and enhance dissemination soyabean varieties. . The capacity of collaborating farming communities and their linkages with researchers and public and private sector for sustainable production of soyabean will be strengthened.

Literature Summary

Over the last two decades, research on soyabean improvement in Uganda has focussed on generating high yield and disease resistant varieties. From the late 1980s to early 1990s, new varieties were introduced and crossed with the local commercial varieties, Kab 1 and Nam 1 (MA and USAID/MFAD, 1988). The varieties soon became susceptible to bacterial pustule and from 1996, the varieties became susceptible to soyabean rust (MAAIF, 1992). Research eventually prioritised disease resistance and generated several elite varieties and eventually some varieties have been released recently (MAAIF, 1992; MAAIF, 2007).

Farmer participation in most of these researches was largely passive, limited to providing land for on-farm evaluations and soil fertility was scarcely considered (Tukamuhabwa *et al.*, 2006). To date, newly released varieties of soyabean and introduced to specific agro-ecologies are highly variable in yields and on farmers fields, yields less than half those reported on station are obtained (FAO, 2004; Tukamuhabwa *et al.*, 2006; MAAIF, 2007). Variability in yields is attributed to heterogeneity

in soil fertility (Giller *et al.*, 2006) and low yields to poor fertility, particularly N and P (Sanchez *et al.*, 1997). This biophysical limitation and lack of farmer involvement in the research to select suitable varieties in different agro ecologies impede the dissemination of this commercial legume across the country.

There is a need to take into account such heterogeneity and diversity of farming systems in management to improve crop productivity. Studies elsewhere in East and Southern Africa have shown that targeting nutrient management resources to heterogeneity in soil fertility increases crop production and resource use efficiencies (Tittone *et al.*, 2007; Zingore *et al.*, 2007). Legumes have been generally recommended for soil productivity improvement in smallholder farming systems where poverty is rampant and nutrient inputs are scarce (Giller, 2001). They can provide N, the most limiting nutrient in smallholder systems. Although legumes have multiple benefits such as providing dietary protein, a source of cash and fixing nitrogen, they however are not a panacea for addressing productivity issues as their contribution to N₂ fixation and productivity can be adversely affected by poor soil fertility and highly acidic conditions (Vanlauwe and Giller, 2006). It has recently also been shown that grain legume production is only economical on fields of good than poor fertility (Ebanyat *et al.*, 2009).

Including effects of variability in soil fertility on agronomic performance of legumes together with socio-economic environment guide in identification of where they best fit i.e. socio-ecological niche (Ojiem *et al.*, 2006). Preference selection of agricultural technologies is best assessed by allowing farmers do the selections. In this way; farmers' needs of new varieties are better addressed could complement on going varietal development efforts to provide farmers with a wider range of varieties to evaluate and adopt under their own conditions. The approach has been successfully used to screen legumes in western Kenya for agro-ecological zones (Ojiem, 2006). Further, broadening the range of soybean varieties disseminated is needed to insure against risk if any problem rust disease occurs to the three rust-tolerant varieties that have so far been released and meeting farmer's preferences and so far there are currently 30 promising genotypes which need screening (MAAIF, 2007).

Through targeting, whether additional nutrient inputs will be required with each of the soybean variety can also be evaluated. Soybean productivity on farmer's fields can be increased

Study Description

through application of Rhizobium inoculants and or application of mineral N and P fertilisers but appropriate recommendations on how to use these inputs with the various soybean varieties in the different agroecological zones in Uganda is lacking (Tukamuhabwa *et al.*, 2006). Generating this information would further enhance efficiency in dissemination of the soybean varieties. Legumes effectiveness to improve productivity of subsequent crops depends on how well they are synchronised within cropping systems. Better results are obtained when cereals are grown following legumes (cf. Osunde *et al.*, 2003; Ncube, 2007). For the system to be attractive, soyabean should be configured with upland rice, which has an economic potential but whose production on smallholder systems is also constrained by low productivity (ADC, 2001; NARO, 2003).

The research will be conducted in Pallisa district representing the Southern and East Lake Kyoga Basin and Lira district representing the Northern tall grasslands Agroecological zones (AEZs) and are well known for soyabean and upland rice production. The difference between zones is mainly due to rainfall, higher in the later than the former and socio- cultural set ups. Two MSc students will be involved in the on-farm research to generate complementary empirical data so as to fully test the following hypotheses: 1. Soyabean varieties best fit to niches of good soil fertility and 2. Socio-economic benefits of soyabean-upland rice cropping systems are larger for varieties on niches of good than poor soil fertility niches.

Site selection and characterisation. Researcher managed experiments will be conducted in collaboration with one community in each ecological zone with farmer groups already under NAADS and have interest in either soyabean or rice as commodity crop. Farmers in those groups will participate in the characterisation of the biophysical, socio-cultural, economic and institutional environment as in the socio- ecological niche framework (Ojiem *et al.*, 2006). This activity will be conducted by the research team and later guide the establishment of on-farm experiments by the MSc. students.

Student research. MSc student 1 will explore ecological adaptations of soyabean varieties to heterogeneity in soil fertility within the agroecological zones. Specific objectives are to (i) determine yield response of soyabean varieties and N₂ fixation as affected by heterogeneity and management interventions (ii) establish farmer's criteria for soyabean preference

assessment, and (iii) Identify varieties preferred by farmers. On-farm experiments will be set on each of the 3 field types (poor, medium and good fertility) and 10 soybean varieties (3 released varieties resistant to rust and 7 elite varieties) will be planted in a split plot experiment with soyabean varieties as main blocks. Each plot (10×10) m will be split into 4 subplots and the following treatments applied: Control, rizhobia, 25 kg N ha⁻¹ and 20 kg P ha⁻¹). Each treatment will be replicated once on 4 fields of each type which may be located on same farm or on different farms. Data to be collected will include; emergence and establishment (counts), reaction to pest and diseases (scoring method), variety nodulation, biomass, and N₂-fixation by N-difference and natural abundance methods at blooming stage (Unkovich et al., 2008), and grain yield maturity. The trials will be conducted in both long and short rains and in each case the experiments will be established on new fields. After the soybean crop upland rice, SUPER NERICA will be planted. MSC student 2 will assess the economic performance of the soyabean- rice cropping system under differing soil fertility classes and management regimes. The specific objectives is to determine (i) the most profitable soyabean variety- upland rice cropping system for each fertility niche (ii) optimise soyabean-rice production on the different soil fertility niches.

Statistical analysis. Yield data and other growth data of both soyabean and rice, will be subjected to statistical analysis using GENSTAT package using principal component analysis to determine genotype x environment interactions to delineate the niches. The scores data on acceptance will be analysed by logistic preference ranking method (Hernandez-Romero, 2000). Profitability analysis will be employed to determine the most profitable cropping system on each fertility niche.

Research Application

Information generated on the socio-ecological niches for the soyabean varieties will be used for better dissemination and enhancing farmer's capacity to sustainably produce soybeans and upland rice

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