Evaluation Of The Response Of Two Soybean Varieties To Rhizobia Inoculation For Improved Biological Nitrogen Fixation.

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ABSTRACT: Soybean (Glycine max .L) is an important food crop in Rwanda and has recently been identified as one of the priority crops for the Crop Intensification Program (CIP) for the country. However, its productivity is low, standing at about 0.8 t/ha against the potential of 3-5 t/ha, depending on the varieties used. The use of organic and inorganic fertilizers to increase soybean productivity is constrained by their high cost to most small scale farmers. Use of farm yard manure is also limited by the unavailability of livestock to most soybean growers. In this regard, the most viable alternative to fertilization would be deployment of Nitrogen-fixing microorganisms to soybean farming systems. These, however, need to first be tested on the available soybean varieties. A field experiment was carried out in Nyarubaka sector of Kamonyi District to evaluate the response of two soybean varieties (Peka6 and SB24) to Rhizobium inoculation without limitation of phosphorus. The experiment was laid down in completely randomized block design with three replicates. The results obtained showed significant differences ($P < 0.05$) in grain yields and nodules mean score between inoculated and no inoculated treatments. The variety Peka6 responded to the Rhizobium inoculants more than SB24. Although further studies need to be conducted to obtain conclusive information on these Nitrogen fixers, the study indicates that Peka6, in combination with the right Rhizobia inoculants, could be recommended to replace conventional fertilization for our poor farming households.

Key words: Inoculation, Response and Soybean varieties

Introduction

Soybean (Glycine max .L) is an important food crop in Rwanda. Between 1997 and 2010, the total soybean production in Rwanda increased from an estimated 6,779 MT to 57,089 MT while the corresponding land area under this crop grew from 13,756 Ha to 72,353 Ha in the same period, MINAGRI [17]. The contribution of soybean in energy, proteins and lipids in 2010 was evaluated at 2%, 8% and 11%, respectively, MINAGRI [17]. Soybean has recently been identified as one of the priority crops for the Crop Intensification Program (CIP) for Rwanda. However, its productivity remains low, the mean grain yield at farmer's level increased from 490 to 800 kg per hectare over the years against 3.500 kg/ha recorded at smallholder' farmers level in Southern Africa, Mapfumo et al [16], Constraints to soybean production identified in Rwanda include soil fertility, climatic variability with unpredictable rainfall and drought, accessibility to improved seeds and poor germplasm. However, among them, low soil fertility remains the most important limiting factor to soybean production in the country. The situation is worsened by cultivation of soils for a long time in many areas with little or no fallows and rotations, combined with lack of use of fertilizers which are either not available or very expensive for most smallholder farmers. The use of organic and inorganic fertilizers is constrained by their high cost to most small scale farmers. The use of farm yard manure is also limited by little or no availability of cattle to most soybean growers. Soybean has a high capacity to improve soil fertility by adding nitrogen from the atmosphere through symbiotic relationship with Rhizobia. On average, 50–60% of soybean N demand is met by biological N2 fixation across a wide range of yield levels and environments and the proportion of plant N derived from fixation decreases with increasing inputs of N fertilizer F. Salvagiotti et al [27]. The estimated quantities of nitrogen which can be biologically fixed from the atmosphere range from 15 to 450 kg per hectare F. Salvagiotti et al [27]. Under optimum conditions of nitrogen fixation, atmospheric nitrogen fixed meets both the needs of the crop and provides residual benefits, Woomer [25]. This represents an alternative to the lack of the use of N-fertilizers in Rwandan farming systems. Research studies on biological nitrogen fixation conducted in Rwanda since 1980 demonstrated the benefits of inoculation of legumes with suitable Rhizobia strains, especially for soybean. Soybean inoculation was estimated to be equivalent to application of 100 kg of urea per hectare, ISAR [12]. The current study was carried out in Nyarubaka sector of Kamonyi District to evaluate the response of two soybean varieties (Peka6 and SB24) to Rhizobium inoculation without limitation of phosphorus.

Materials and methods

Experimental site

The trial was conducted on farmers' fields in Mugereka village, Gitare cell, Nyarubaka sector of Kamonyi District in Southern province of Rwanda. Kamonyi district is located in the central plateau, with 404.8 inhabitants per km2, with rainfall ranging between 1200-1400 mm and an average temperature of 20 ˚C. The study site was located at S 02005'55.1'', E 029048'35.6'' and 1783 masl. The soil samples were taken and chemical analysis was done before planting: pH water: 5.07, pH Kcl: 4.50, N: 0.09% and P: 296.66 ppm. Two soybean varieties, Peka6 and SB24 were used and planted at a spacing of 40 cm inter-row and 5 cm intra-row with one seed per hole. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replicates. Fertilizer application rates: TSP was applied using a uniform rate of 30 kg P ha^{-1}; Urea was applied at a rate of 100 kg of Urea/ha. Seeds were inoculated prior to planting with USDA 110 strain of Rhizobia at a rate of 10 g of inoculum per kg of seeds.

Data collection

Parameters included nodules score, dry biomass and yields. Biomass was taken at full-pod. 10 plants taken randomly in every plot were cut at ground level, put in clean bags and flesh field weight were measured. After air dry the samples followed by drying at 65^{0}C to constant weight and

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were recorded. At this stage, the plants cut were uprooted and all nodules were counted and recorded. At harvesting time, all pods from the net plot in all treatments were collected and the total fresh weights were recorded. After harvesting the pods, pods were separated into grains and husks and measured separately.

Statistical analysis
Data was subjected to analysis of variance (ANOVA) procedure using Genstat statistical software (4th edition). Where significant differences between means were detected, means were separated using the least significant difference test (LSD). A significance level of α = 0, 05 was used in all analyses.

Peka6: soybean variety

SB24: soybean variety

Results

Nodulation counts
Significant differences (P < 0.001) among inoculated, non inoculated and urea treatments for both Peka6 and SB24 varieties were observed for the mean nodules. However, there is no significant difference in term of response to inoculation between the two varieties. Low nodulation was observed in none inoculated and plants treated for the two varieties while the highest nodulation were recorded in inoculated treatments. Figure 1 below show effect of inoculation & urea application on nodulation of two soybean varieties.

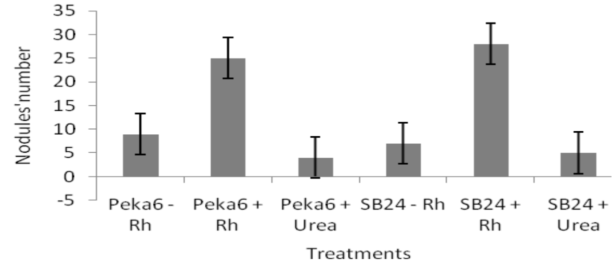

Fig.1: *Effect of inoculation & Urea application on nodulation of two soybean varieties*

Key: Peka6 – Rh: no inoculated Peka6 variety, Peka6 + Rh: inoculated Peka6 variety, Peka6 + urea: Peka6 variety with Urea application, SB24 – Rh: no inoculated SB24 variety, SB24 + Rh: Inoculated SB24 variety, SB24 + Urea: SB24 variety with Urea application.

Biomass production
Results on biomass production showed no significant differences among treatments and the two varieties (p=0.172). Figure 2 illustrates effect of inoculation and urea application on dry biomass of two soybean varieties.

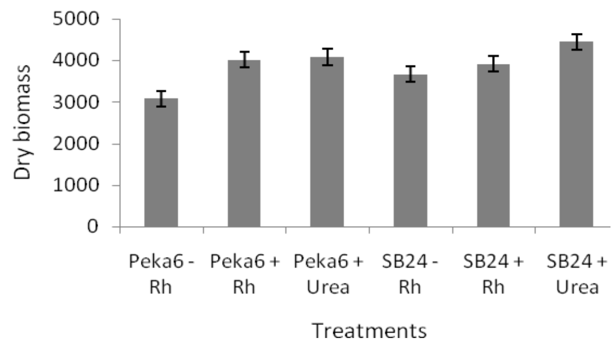

Fig.2: *Effect of inoculation & Urea application on dry biomass of two soybean varieties*

Key: Peka6 – Rh: no inoculated Peka6 variety, Peka6 + Rh: inoculated Peka6 variety, Peka6 + urea: Peka6 variety with Urea application, SB24 – Rh: no inoculated SB24 variety, SB24 + Rh: Inoculated SB24 variety, SB24 + Urea: SB24 variety with Urea application.

Grain yield
The results obtained showed significant differences among treatments and between the two varieties (p =0.007). There was no significant difference between none inoculated and inoculated Peka 6 while non inoculated Peka 6 was different from other treatments. No significant difference was observed between non inoculated and inoculated SB 24. Figure 3 below shows the effect of inoculation and urea application to the grain yields of SB24 and Peka6 varieties.

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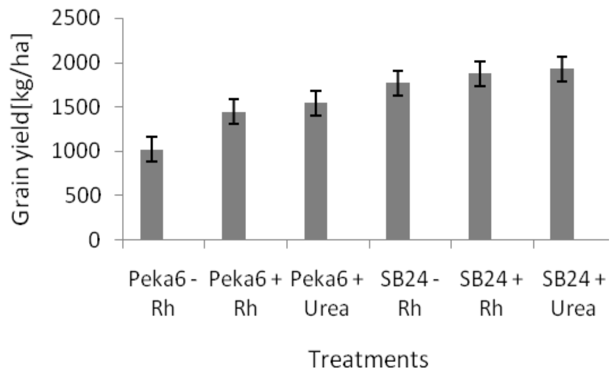

Fig.3: *Effect of inoculation & Urea application on grain yield of two soybean varieties*

Key: Peka6 – Rh: no inoculated Peka6 variety, Peka6 + Rh: inoculated Peka6 variety, Peka6 + urea: Peka6 variety with Urea application, SB24 – Rh: no inoculated SB24 variety, SB24 + Rh: Inoculated SB24 variety, SB24 + Urea: SB24 variety with Urea application

Discussion

Mean nodules showed that rhizobia inoculation enhanced nodulation of the two varieties. This confirms results obtained by Mayz et al [26]. Nodulation for no inoculated treatments could be due to the presence of indigenous rhizobia populations in the soil, Giller [16]. However, for urea treatments, this nodulation is a sign of low level of nitrogen applied in the soil which could not satisfy all N requirements of the plants, Hungria et al [11]. The non significant differences among treatments and varieties showed that probably BNF was not as effective as expected even nodulation is important, Dhami and Prasad [9]. The non significant increase of biomass for urea treatments could be explained by the insufficiency of urea amount applied or coupled with other nutrient deficiency, Laditi et al [14]. Significant differences of none inoculated Peka6 and other treatments including none inoculated SB24 for grain yield showed that Peka6 could be a specific variety and require inoculation to fix nitrogen while SB24 responsed to the characteristics of a promiscuous variety with the capacity of fixing nitrogen without inoculation, Gitonga et al [15] and Muhammad [19]. The potential to yielding for SB24 seems to be high compared to Peka6. Significant differences for grain yield between none inoculated Peka6 and other treatments demonstrated also the efficiency of inoculation especially for Peka6 variety. The no significant differences of urea treatments and inoculated treatments showed that inoculating soybean in this area is equivalent to application of 100 kg of Urea/ha.

Conclusion and Recommendation

The main objective of this study was to determine the response of soybean varieties to Rhizobia inoculants application to improve biological nitrogen fixation without limitation of Phosphorous It was also to verify if the use of Rhizobia inoculants for those varieties increase their productivity and may replace inorganic fertilizers as mineral fertilizers are expensive. Results showed a good response of the two varieties to Rhizobia inoculation. The presence of nodules to non inoculated treatments and urea treatments proves the existence of rhizobia population in the soil. Nodules on urea treatments also indicate that the amount of urea applied is not sufficient to satisfy all N requirements of the plants. In term of biomass, no significant differences were observed among treatments and varieties showing that probably BNF was not as effective as expected even nodulation is important. The non significant increase of biomass for urea treatments confirms the insufficiency of urea amount applied. In general, grain yields for all treatments indicate the good performance of Rhizobia inoculation for the two varieties. In fact, inoculated treatments for those varieties are equivalent to those received 100 kg of urea per hectare, but not different with non inoculated SB24. However, Peka6 benefited more than SB24 which is a promiscuous variety. Further investigations need to be conducted in order to evaluate and characterize rhizobia indigenous population in the soils. It will be also useful to investigate more and evaluate the effect of micronutrients such as Mo and Co for the success of nitrogen fixation.

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