JOURNAL OF ADVANCED BOTANY AND ZOOLOGY
Journal homepage: http://scienceq.org/Journals/JABZ.php

Research Article Open Access

Effects of *Stylosanthes guyanensis* and soybean inoculum on the growth and production of soybean (*Glycine max* L.) in eco-climatic conditions of Kinshasa (DR Congo)

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Received: October 24, 2015, Accepted: February 7, 2016, Published: February 7, 2016.

ABSTRACT

Soybean (*Glycine max* L.) is a legume grown mainly for its seeds rich in proteins with the proportions of 36.5%. In Democratic Republic of the Congo (DRC or DR Congo), there are several varieties of cultivated soybeans. Since there is a diversity of soils cultivated by farmers, some varieties do not always express their potential. The reason why a study was conducted in N'djili-Brasserie crop scientific station from April20 to August12, 2013 for the first test and from October 2, 2013 to January 12, 2014 for the second test. This study was designed to compare the two used fertilizers, to bring out the best dose of these fertilizers enabling the farmers of this country to increase their production and to evaluate the yield of the variety TGX 888-49 C. The results of the test conducted according to a randomized complete block system with four repetitions showed that *Stylosanthes guyanensis* (6 Kg/m^2) has positively influenced the studied parameters as well in the first test as in the second test of which the best yield was that observed from the first test (2133 Kg/ha) while the lowest yield was observed in the second test (1175 kg/ha). Given the findings, *Stylosanthes guyanensis* biomass can be retained and recommended as organic fertilizer for soybean production in Kinshasa and its surroundings.

Key words: Yield, legume, association, diet, Democratic Republic of the Congo

INTRODUCTION

In all the Third World countries in general and in DRC in particular, the food problem remains at the center of all the people's concerns. This situation is due to the fact that animal proteins are scarcer and scarcer because of the low income of people in different communities [1]. To solve this problem and reach a reliable food safety, we can resort to the cultivation and the valorization of plant species having high nutritional values[2].

According to [3], soybean is a legume richer in proteins with (proportions of 36.5%), and in potassium which can provide the body with 3 to 6 milligrams of potassium each day. However, as its production is not growing, soybean should benefit from research efforts so that farmers grow it, and that its production may be higher than possible [4]. Since the chemical composition of soils where our crops grow makes more and more fear of an excess of potassium, the contribution of *Stylosanthes guyanensis* used as green fertilizer and soybean inoculum can improve physical and chemical properties of the soil with a view to increase this crop yield [5]. This work has as objective to compare the two natural fertilizers used with a view to bring out the best dose of these fertilizers that can enable farmers of this country to increase their production and to evaluate the yield of this variety under study. In addition, it would increase soybean production (thanks to natural fertilizers) in order to contribute to food safety. In the particular case of this system, there is not to our knowledge any data relating to Kinshasa city. Thus, this study would allow making soybean available to the people of Kinshasa city and its surroundings.

MATERIALS AND METHODS

Experimental Site

The experimentation was carried out at the crop scientific station of N'djili-Brasserie, located about 30 km from Kinshasa downtown (4° 29' South latitude and 15° 23' East longitude, 471.31 m of altitude) in DRC. The previous farming consisted of a fallow land dominated by *Cyperus rotundus* and *Cynodon dactylon*. Kinshasa soils are mainly sandy soil texture accompanied by a few coarse elements. The low water retention capacity of these soils gives them a marginal use for agriculture [6]. However, the soil presents a clay texture in the low swampy ground. This soil presents a particular texture with an acid pH (i.e. 4.72). The major minerals are a low proportion or 0.49% for nitrogen; 0.039% for potassium and 0.48% for calcium.

The test was conducted from April20 to August12, 2013 (against growing season A/2013) for the first test and from October 2, 2013 to January 12, 2014 (growing season A/2013) for the second test. The temperature during the period of the test varied between 25.2 and 26.9°C. The crop scientific station of N'djili-Brasserie is bounded in the East by the N'djili River, South-East by the Mati River and North by the Mitindi River. The Marubakambaka River rises inside the station, crosses it

from west to east and then flows into the N'djili River [6]. According to Koppen's classification, our experimental site belongs to climateAw_4. It is a hot and humid tropical climate with four months of dry season. The rainy season ranges from mid-September to mid-May, with two extreme months of maximum precipitation, November and April. It is quite frequently interrupted by a short dry season fluctuating between December end and February. The average temperature ranges from 21 to 26°C in the dry season and from 26 to 32 °C in the rainy season [2].

Plant Material

The plant material used in our experimentation was a variety of soybean coming from National Seed Service (SENASEM). It is TGX888-49C. The choice focused on this variety is explained by its adaptation in this country.

Methods

The test was conducted according to a randomized complete block system with 4 repetitions. Each block representing a repetition, included 6 parcels corresponding to the studied treatments, a total of 24 parcels. The dimensions of the parcels were 1 m long and 1 m wide (or 1 m^2). The field had 59.5 m^2 or 8.5 m long and 7 m wide. Two consecutive blocks were separated by a distance of 1 m and while two consecutiveparcels were spaced 0.5 m. The ground preparation began by clearing followed by labor, harrowing and delimitation of the blocks and plots. After preparing the ground, the procedure was to apply different treatments in different plots. We proceeded to direct seeding with three seeds per seed hole spacing 40 cm x 20 cm (54 plants per plot) to a depth of about 3 cm. The test was repeated once in the old days. Maintenance care focused on no-marriage and refilling which were carried out 12 days after sowing. Weeding was done once every two weeks from sowing and second hoeing a month after sowing. The data were recorded from a sample of 20 randomly selected plants per experimental plot. The observations focused on vegetative parameters and production parameters.

Statistical analysis

For each studied treatment, the collected data were analyzed according to the method of analysis of variance, ANOVA witha 5% likelihood level. The test for the least significant difference (LSD) was used to compare the results of the different treatments applied. All these tests are carried out using the STATISTIX 8.0software.

RESULTS AND DISCUSSION

Vegetative parameters relating to the first test

The results relating to the vegetative parameters obtained in the first test are given in Table 1. Table1. Influence of *Stylosanthes guyanensis* and soybean inoculum on the vegetative

Table1. Influence of Stylosanthes guyanensis and soybean inoculum on the vegetative

Treatments	Shoot rate	Node diameter	Plants height
	(%)	(mm)	(cm)
T_0	86.3a	2.6c	20.6c
T_1	89.5a	2.9c	23.1c
T_2	88.5a	3.3b	29.6b
T_3	85.3a	4.0a	34.2a
T_4	83.8a	3.3b	29.0b
T_5	85.8a	3.3b	27.8b
Average	86.5	3.23	27.37
CV	5.12	6.26	9.04

***Legend**: T_0: Control; T_1: Contribution of 0.16 g of soybean inoculum; T_2: Contribution of Stylosanthes guyanensis: 3 kg/m^2; T_3: Contribution of Stylosanthes guyanensis: 6 Kg/m^2; T_4: Contribution of Stylosanthes guyanensis: 1.5 Kg/m^2 and T_5: Contribution of 1.5 Kg/m^2 of S. guyanensis + 0.08 g of soybean inoculum. The numbers in the columns followed by the same letters are not significantly different according to the test of the Least Significant Difference (LSD) with 5% likelihood.*

The result relating to the shoot rate of the five treatments in relation to the control indicates that all treatments used are of good quality because their shoot rate is over 85% except for T_4 which gave a lower result (83.8%). In addition, statistical analysis with 5% likelihood level shows no significant difference between the different treatments (LSD = 6.68). Numerically, the highest shoot rate was recorded in T_1 (89.5%), followed by T_2 (88.5%). T_4 (83.8%) presented a lower percentage than the other treatments used in competition. The data collected on plant height inblossom (i.e. 30 days after sowing) indicate that T_3, T_2 and T_4 have a greater height than the other treatments (34.2, 29.6 and 29 cm) while the lowest level was observed in control T_0 (20.6 cm). Statistical analysis reveals a significant difference between the treatments witha 5% threshold. (LSD = 3.73). Regarding the node diameter, it is apparent from Table 1 that the highest nodediameter was observed in T_3 (4.0 mm) followed by the treatments T_4 (3.3 mm) and T5 (3.3 mm). The lowestnodediameter was noticed in T_0 (2.6 mm). Statistical analysis with a 5% likelihood threshold

noted that there are significant differences between the treatments (LSD = 0.31).

Production parameters relating to the first test

The results relating to the number of pods per plant, number of seeds per pod; the weight of 100 seeds; production per plot and the estimated yield per hectare are presented in Table 2.

The average number of pods per plant counted on each plant indicates that the treatments T_3, T_5 and T_2 present respectively a higher number of pods than the others. In addition, T_0 presented less pods. Statistical analysis with a 5% likelihood level indicates that there is a significant difference between the treatments (LSD 0.05 = 2.37).

Relatively to the number of seeds per pod, it is apparent from Table 2 that this number is the same for all the treatments and statistical analysis showed that there is no significant difference between the treatment means. As regards the weight of 100 seeds, this ranged from 11.50 to 12.48 grams. The numerical data showed a clear difference between the treatments whose treated plants of T_3 gave the higher weight compared to the other treatments (12.48 grams). Statistical analysis showed significant differences between the treatments. Indeed, this result allows considering this parameter as a criterion for selection of these treatments for their spread. The results relating to production per plot show that T_3 gave the highest production (0.2133 kg per parcel). The lowest production was obtained with T_0 (0.0689 grams). Statistical analysis showed significant differences among the studied treatments (LSD 0.05 = 0.01).

Estimated yield

The average yield obtained is 1309.5 kg per hectare and statistical analysis of data with the 5% likelihood level indicates significant differences between the treatments (LSD 0.05 = 63.26). The yield obtained with T_3 is far superior to the other treatments (2133 kg/ha) and the lowest was observed in T_0 (689 kg/ha).

The second test consisted of repeating the experimentation on the same piece of land in order to compare its results to those of the first test. The results obtained in the second test are reported in Tables 3 and 4 below.

Vegetative parameters relating to the second test

The results relating to the shoot rate, node diameter and plant height are presented in Table 3.

Table 2. Results related to production parameters

Treatments	**Number of pods per plant**	**Number of seeds per pod**	**weight (g) of 100 Seeds**	**Production per plot (kg)**	**Estimated yield (kg/ha)**
T_0	4d	2a	11.15c	0.0689e	689e
T_1	5d	2a	11.55bc	0.1053d	1053.0d
T_2	11bc	2a	11.98ab	0.1418b	1418b
T_3	16a	2a	12.48a	0.2133a	2133.0a
T_4	8c	2a	11.63bc	0.1202c	1202c
T_5	12b	2a	12.03ab	0.1364b	1364b
Average	9	2	11.8	0.1309	1309
CV	16.93	1.2	3.76	6.83	6.83

***Legend**: **T_0**: Control; **T_1**: Contribution of 0.16 g of soybean inoculum; **T_2**: Contribution of Stylosanthes guyanensis: 3 kg/m^2; **T_3**: Contribution of Stylosanthes guyanensis: 6 Kg/m^2; **T_4**: Contribution of Stylosanthes guyanensis: 1.5 Kg/m^2 and **T_5**: Contribution of 1.5 Kg/m^2 of S. guyanensis + 0.08 g of soybean inoculum. The numbers in the columns followed by the same letters are not significantly different according to the test of the Least Significant Difference (LSD) with 5% likelihood.*

Table 3. Influence of Stylosantes guyanensis and soybean inoculum on vegetative parameters of soybean.

Treatments	**Shoot rate (%)**	**Node diameter (mm)**	**Plants height (cm)**
T_0	71.5c	1.9d	18.4c
T_1	72bc	2d	20.1c
T_2	82a	2.3bc	26.1b

T_3	79ab	3.1a	31.4a
T_4	74bc	2.2c	25.2b
T_5	76abc	2.5b	26.7b
Average	75.8	2.3	24.6
CV	6.24	7.43	11.53

***Legend**: T_0: Control; T_1: Contribution of 0.16g of soybean inoculum; T_2: Contribution of Stylosanthes guyanensis: 3 kg/m^2; T_3: Contribution of Stylosanthesguyanensis: 6 Kg/m^2; T_4: Contribution of Stylosanthes guyanensis: 1.5 Kg/m^2 and T_5: Contribution of 1.5 Kg/m^2 of S. guyanensis + 0.08 g of soybean inoculum. The numbers in the columns followed by the same letters are not significantly different according to the test of the Least Significant Difference (LSD) with 5% likelihood.*

It is apparent from Table 3 that the test average is 75.75% among the different treatments and the highest average is obtained with T_2 (82%) followed by T_3 (79%). Statistical analysis did not find any significant differences between the different treatments (LSD 0.05 = 7.12). Compared to the node diameter, it was observed that the plants treated with T3 (3.1mm) presented a higher value followed by those treated with T_5 (2.5 mm). Statistical analysis showed that there are significant differences between the different treatments (LSD 0.05 = 0.26). As for the plant height, it was observed that the plants treated with T_3 showed a greater height compared to the other treatments (31.4 cm), followed by those treated with T_5 (26.7 cm). The large average among the treatments is 24.6 cm. Statistical analysis with a 5% likelihood point noted that there are significant differences between the treatments (LSD 0.05 = 4.28).

Production Parameters

The results relating to the number of pods per plant, the number of seeds per pod; the weight of 100 seeds; production per plot and the estimated yield per hectare are presented in Table 4.

Table 4. Results related to production parameters

Treatments	**Number of pods per plant**	**Number of seeds per pod**	**weight (g) of 100 seeds**	**Production per plot (kg)**	**Estimated yield (kg/ha)**
T_0	2e	2a	10.7c	0.0243e	243e
T_1	4d	2a	11.35bc	0.0419d	419d
T_2	8b	2a	11.58ab	0.0810b	810b
T_3	11a	2a	12.25a	0.1175a	1175a
T_4	6c	2a	11.58ab	0.688c	688c
T_5	8b	2a	11.88ab	0.0824b	824b
Average	6	2	11.55	0.0693	693
CV	9.15	1.2	4.44	8.77	8.77

***Legend**: T_0: Control; T_1: Contribution of 0.16 g of soybean inoculum; T_2: Contribution of Stylosanthes guyanensis: 3 kg/m^2; T_3: Contribution of Stylosanthes guyanensis: 6 Kg/m^2; T_4: Contribution of Stylosanthes guyanensis: 1.5 Kg/m^2 and T_5: Contribution of 1.5 Kg/m^2 of S. guyanensis + 0.08 g of soybean inoculum. The numbers in the columns followed by the same letters are not significantly different according to the test of the Least Significant Difference (LSD) with 5% likelihood.*

Compared to the number of pods per plant, the highest value was observed with the treatmentT_3 (11) followed by T_2 (8) and T_5 (8). The recorded numerical data showed the clear differences between the treatments and that the plants grown in plots treated with T_3 gave more pods. From these findings, statistical analysis shows significant differences with 5% likelihood level (LSD 0.05 = 0.88) between the different treatments on soybean crop. As far as the number of seeds per pod is concerned, it is clear from Table 4 that the number of seeds per pod remains the same for all the treatments applied. Statistical analysis showed no significant difference between the treatment means. As for what concerns the weight of 100 seeds, the numerical data showed a clear difference between the treatments whose plants subject to the treatment T_3 gave a higher weight compared to the others. This weight ranged from 10.7 to 12.25 grams. Statistical analysis showed significant differences between the treatments (LSD 0.05 = 0.77). With regard to production per plot, the plants subjected to the

treatment T_3 gave the highest production compared to the others (0.1175 kg per plot). The lowest production was obtained with the treatment T_0 (0.0243 kg per plot). Statistical analysis showed significant differences between the treatments (LSD 0.05 = 9.16).

Estimated yield

The estimated yield gave an average of 693 Kg/ha. The highest yield was obtained with the plants which were grown in the plots treated with T_3 (1175 Kg/ha). Statistical analysis of the data indicates significant differences between the treatments (LSD 0.05 = 42.97).

Among the six treatments used during the test, the findings showed that the plants fertilized with T_3 (6 Kg of *Stylosanthes guyanensis*per m^2) gave the highest scores in the 1st and 2nd test compared to those fertilized with soybean inoculum and control and it is the best score in the first test. The estimated yield from the first test ranged from 689 to 2133 kg/ha that generally correspond to the average yield in tropical regions ranging from 500 to 2250 kg/ha [7]. The best results obtained with T_3 regarding the studied parameters are justified by significant needs for nitrogen which soybean crop requires for its production [8]. The lowest production was recorded in the control plants and those grown during the second test in which the estimated yield ranged from 243 to 1175 Kg/ha not corresponding to the interval of the average estimated yield. The lowest yield obtained with control in the first test is due to poverty and nitrogen soil and that recorded in the second test is due to the non-adaptation of this variety of soybean where this one fears excess humidity [9]. Because the contribution of *Stylosanthes guyanensis* used as green fertilizer and soybean inoculum can improve the physical and chemical properties of the soil and increase crop yields, the application of these fertilizers has influenced positively the results obtained with a predominance of the plants fertilized with *Stylosanthes guyanensis* [10]. Compared to the results obtained by [1] at the same station by means of the use of soybean inoculum on soybean crop, the results found from our test (2133 kg/ha) are far superior to those that he had found in 2002 with an average estimated yield 712.75 Kg/ha.

CONCLUSION

The objectives of our work were to compare two fertilizers, *Stylosanthes guyanensis* and soybean inoculum,to bring out the best dose of these fertilizers and to assess the yield of this variety of soybean in Kinshasa/N'djili Brasserieecological conditions. The findings showed that the treatment T_3 (6 Kg of *Stylosanthes guyanensis* per m^2) significantly influenced all the parameters observed except for the shoot rate where the treatment T_2 gave a higher shoot rate than the other treatments. The highest result obtained with the treatment T3can be justified by the soil fertility improvement due to the contribution of the biomass of *Stylosanthes guyanensis*. The latter is capable of providing large amounts of nitrogen (70 to over 200 kg/ha/year) and of recycling the bases (Boron, Copper, etc.) and of increasing crop yields. The lowest yield was observed with the treatmentT_0 (689 kg/ha). Given the findings, it appears clearly that the biomass of *Stylosanthes guyanensis* can be used as organic fertilizer on soybean production (*Glycine max*) in N'djili-Brasserie crop scientific station. Thus, we suggest that further studies should be continued for the purpose of determining the maximum amount of the biomass of *Stylosanthes guyanensis* to use so as to give a higher yield than that obtained.

ACKNOWLEDGMENTS

The authors are indebted to "Académie de Recherche et d'Enseignement supérieur (ARES, Belgium)" for the research grant PAH-2015 ARES/UNIKIN offered to Bangata B.M.

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Citation: Koto-te-Nyiwa Ngbolua *et al* (2016). Effects of *Stylosanthes guyanensis* and soybean inoculum on the growth and production of soybean (*Glycine max* L.) in eco-climatic conditions of Kinshasa DR Congo. J. of Advanced Botany and Zoology, V4I1. DOI: 10.15297/JABZ.V4I1.03.