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The Role of Nitrogen-Levels and Foliar Fertilizer at Critical Stages for Inoculated Soybean Growth and Yield Improvement in Northern Savannah Zone Of Ghana

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Abstract

Need for the nutrient supplement at certain critical stages of soybean development to sustain successful growth, seed formation, pod filling and quality grain yield cannot be underestimated. Hence, the response of soybean "Jenguma" growth, nodulation and grain yield to Bradyrhizobium japonicum inoculum and mineral fertilizer application at various growth stages was evaluated on the research farm of CSIR-Savanna Agricultural Research Institute (SARI), Ghana. The experiment consisted of three factors i.e. Inoculation (+INO and –INO), Nitrogen levels (0, 25, 50 and 75 kg N ha^{-1} (as starter and top dressed at beginning bloom, R1 - stage)) plus Foliar fertilizer (Boost extra (BX) applied at R1 – R4 stage) 4 liters ha^{-1} (+ and -)). Giving sixteen combinations in all, replicated thrice. Basal application of 30 kg P_2O_5 and K_2O ha^{-1} each was applied. The experiment was a Randomized Complete Block Design. The plant height and canopy spread response to starter N (25 kg N ha^{-1}) is proof that a minimum level of N is necessary for soybean establishment. The treated plots indicated a significant ($P<0.05$) influence on soybean pod formation and grain yield performance as compared to Control. In fact, a significant (94 %) grain yield increase was produced from 50 kg N ha^{-1}+BX compared to Control. Likewise, the lowest N-level (25 kg N ha^{-1}) and it's combinations with BX or INO and the use of 25 kg N ha^{-1}+INO+BX also gave substantial grain yield increase (50 % and above) over Control. These are an indication that the appropriate timing of N, it's top dressing and foliar fertilizer application at certain growth stages of soybean enhanced inoculated soybean growth and grain yield. Hence, the use of fertilizer and its top dressing (N and foliar fertilizer) is paramount in augmenting inoculated soybean production in the study area. The choice of fertilizer, rate and time of application depend on the farmer's choice.

Key Word: *Soybean, Canopy spread, Bradyrhizobium japonicum, Leaf senescence, Foliar fertilizer*

INTRODUCTION

Nitrogen (N) and foliar fertilization are not traditional nutrient management practices for soybean production. Because soybean is a legume plant is expected to obtain adequate N through mineral N assimilation and symbiotic N_2 fixation (Hartwig, 1973). However, because of soybean high N requirement farmers have difficulty in satisfying its N demands. Hence, mineral N fertilization is a crucial factor in oilseed legume production (Rathke et al., 2005). Studies carried out on the effect of fertilizer - N on soybean growth and N_2 fixation showed that N fertilization increased growth but reduced N_2 fixation by causing a reduction in nodule number and nodule weight (Chen et al., 1992; Starling et al., 1998). This however is said to be dependent on quite a number of factors including the soil type, climate, farming system, farmer's ability to afford fertilizer and applying it at the required rate and time (Adewoyin, 2014). Few studies have evaluated the effect of

Nitrogen (25 kg N ha^{-1}), it's top dressing (25 kg N ha^{-1} and 50 kg N ha^{-1}) at beginning bloom (R1) stage and foliar fertilizer (macro and micronutrients) application at beginning bloom to beginning seed (R1 – R4) stages on soybean growth and yield in the Savanna agro ecological zone of Ghana.

Inoculation is a technology used for the manipulation of rhizobia populations for improved crop productivity and soil fertility (Keyser and Li, 1992). Inoculation can lead to the establishment of large populations of rhizobia (rhizosphere) and improve nodulation and N_2 - fixation (Peoples et al. 1995). However, soybean response to inoculation (van Kessel and Hartley, 2000) depends on inherent field variability and differences in environmental and edaphic conditions. The response of legumes to inoculation depends to a large extent on the number of rhizobia already established in the soil, the availability of soil nitrogen and the management practices put in place (Thies et al., 1991). In general, (Araujo et al., 1994), the effective and efficient use of inoculation occurs in soils that are depleted or contain low indigenous rhizobia population or when there is an established but inefficient rhizobia population. A positive response of nodulation, shoot biomass and grain yield to rhizobia inoculation has been reported (Dorivar et al., 2009) contrarily increased nodule number, nodule dry weight but not shoot biomass, dry root weight and grain yield were also reported (Otieno et al., 2009). These variations in response to inoculation could be due to many factors including legume genotype, climatic, edaphic and management factors (Giller, 2001; Giller and Wilson, 1991; Sanginga et al., 1995).

Soybean flowering phase is immediately followed by leaf senescence alongside pod formation and seed filling**.** The peak of flowering is the peak of nodule activities (BNF) after which the nodules rupture and the leaf falls. Studies have shown that the use of nutrient supplements at late vegetative, early or late reproductive stage prolongs plant vegetative stage and therefore complements biological nitrogen fixation, which tends to decline at this stage to sustain pod formation and seed filling (Ashour and Thalooth, 1993). Yield increases of 27 to 31 % resulted when liquid N – P – K - S fertilizer was applied at late reproductive stages (R5 to R6; Garcia and Hanway 1976). The use of foliar fertilizer also resulted in an increase in yield (Wesley et al., 1998; Mallarino et al., 2001). On the contrary, neither increase nor decrease in the yield of soybean to the use of foliar fertilizer was observed in some trials (Boote et al., 1978; Parker and Boswell 1980). While, in another instance the application of foliar micronutrients on the double inoculation of fungi - Rhizobium increased grain yield (Clement et al., 2013). Similarly, the importance of some micronutrients such as boron on soybean nitrogen fixation and seed yield has been indicated (Ross et al., 2006; Bellaloui et al., 2010). In view of all these controversial reports there is a need to investigate the response of inoculated soybean to N fertilizer levels (split application) and foliar fertilizer (boost extra) especially in the Northern region of Ghana. The hypothesis of this research is that the starter N and top dressing (N and foliar fertilizer) at certain critical growth stages of soybean will sustain its development and consequently increase yield.

MATERIALS AND METHODS

Experimental site

This experiment was carried out at the experimental field of CSIR-Savanna Agricultural Research Institute (SARI), located about 16 km west of Tamale, and lies on latitude 09^{o} 23'22.4'' N and longitude 01^{o} 00' 12.1" W, at an elevation of 195 m above mean sea level of the interior Guinea Savanna agro - ecological zone of Ghana. The rainfall is monomodal (April/May – October), and a dry season with severe harmmattan wind is occurring between December and January. The total annual rainfall ranges from about 800 to 1,500 mm (SARI, 2009) and the annual temperature ranges from a minimum of 13 ^{o}C to a maximum of 40 ^{o}C, with a mean of 28 ^{o}C. The experimental field had been previously cultivated to hot pepper for three consecutive years. The soil of the study area is the Tingoli series classified as Ferric Luvisol (FAO, 1988).

Soil sampling and preparation

Composite soil samples for laboratory analysis were taken from (0 – 20 cm depth) the experimental site prior to land preparation. The samples were taken randomly across the field using a soil auger. Samples were then air dried, thoroughly mixed and passed through a 2 mm mesh sieve and packaged for laboratory analyses.

Determination of soil chemical and physical properties

Soils collected from the experimental field were analyzed for pH in a 1:2.5 suspension of soil to water ratio using electrometric method, organic carbon content by the modified Walkley Black procedure (Nelson and Sommers, 1982), total N Kjedahl by distillation procedure (Bremmar and Mulvaney, 1982), available phosphorus by Bray 1 (Bray and Kurtz, 1954) and potassium using flame photometry (Helmke and Sparks, 1996). Exchangeable bases (Ca^{2+}, Mg^{2+} K^{+}, Na^{+}) were determined using 1N NH_4OAC extract (Thomas, 1982), after which Ca^{2+} and Mg^{2+} were determined from Atomic Absorption Spectrometer, while K^{+} and Na^{+} were obtained by the flame photometer. Exchangeable acidity (Al^{3+} and H^{+}) was determined by the titrimetric method after extraction with 1N KCL (Mclean, 1982). Copper, iron and manganese in the soil were determined using the diethylenetriamine pentaacetic extraction method. Ten (10) grams air dried soil was weighed into separate plastic bottles for Cu, Fe and Mn after which a hundred milliliters DPTA extract was added to each. It was shaken for 2 hours and filtered with what man No. 42 filter paper. Their values were all read on an Atomic Absorption Spectrophotometer using the appropriate standards. Soil physical properties were also determined using Bouyoucous hydrometric method (Bouyoucous, 1962).

Rhizobia population estimation by Most Probable Number method (MPN)

The estimation of the rhizobia populations in the study fields was carried out using the most probable number method (MPN) (Vincent, 1970). Uniform seeds of good viability were surfaced sterilized with alcohol and hydrogen peroxide (Somasegaran and Hoben, 1994). The seeds were pre-germinated in Petri dishes containing moist sterile cotton wool and incubated between the temperatures of 20 °C and 30 °C. Seeds were then transferred to plastic growth pouches containing Broughton and Dilworth N-free (Broughton and Dilworth, 1970) plant nutrient solution aseptically with the help of forceps. The growth pouches were arranged in a wooden rack and kept in the greenhouse awaiting inoculation.

Fivefold dilutions of each of the samples were made as follows: Five different test tubes were filled with 20 ml distilled water. With a pipette, a 5 ml solution was transferred from the 10^{-1} dilution (which was prepared by vigorously shaking 100 g of the sample in 400 ml of the sterile distilled water) into one of the five different test tubes. Series of dilutions were then made from 10^{-1} to achieve 10-6 finally. Each growth pouch was inoculated with 1ml of the dilutions replicated four times for each dilution series, using different pipette tips and started from the highest dilution to prevent contamination. The plants were watered with sufficient N – free nutrient solution when required. Nodulation was assessed after twenty-eight days after which the total number of pouches that nodulated for each replicated dilution unit was used to determine the number of rhizobia per gram of soil using charts generated by MPNES software (Woomer et al. 1990).

Land preparation and layout

The land was ploughed, harrowed and ridges were constructed mechanically. Plots measuring 7 m by 7 m were demarcated for planting. An alley of 2 m between plots and 3 m between blocks was also constructed.

Inoculation

Soybean seeds (var. Jenguma) were inoculated prior to planting with peat - based inoculum of *Bradyrhizobium japonicum* at the rate of 5 g per one kilogram of seed using the slurry method (Woomer et al., 1994).

Planting

Soybean seeds were planted at two seeds per hill on ridges made at 0.05 m within rows and 0.75 m between rows covered with soil and thinned to one seed per hill two weeks later. Planting was done starting with the un-inoculated plots followed by the inoculated plots to avoid contamination.

Treatments

The treatments used for the study were: T_1=25 kg N ha^{-1}, T_2=50 kg N ha^{-1}, T_3= 75 kg N ha^{-1}, T_4=[1]Boost extra (BX), T_5= INO, T_6=25 kg N ha^{-1}+*Bradyrhizobium japonicum* (INO), T_7=50 kg N ha^{-1}+INO, T_8=75 kg N ha^{-1}+INO, T_9=BX+INO, T_{10}=25 kg N ha^{-1}+BX, T_{11}=50 kg N ha^{-1}+BX, T_{12}=75 kg N ha^{-1}+BX, T_{13}=25 kg N ha^{-1}+BX+INO, T_{14}=50 kg N ha^{-1}+BX+INO, T_{15}=75 kg N ha^{-1}+BX+INO, T_{16}=Control

Fertilizer application

Nitrogen was applied as ammonium sulphate. The 50 and 75 kg N ha^{-1} treatments were applied in two splits; 25 kg N ha^{-1} was applied seven days after planting and top dressed at beginning bloom with 25 and 50 kg N ha^{-1} (to give 50 and 75 kg N ha^{-1}) respectively. Triple superphosphate and Muriate of potash were applied basally (30 kg ha^{-1} each) seven days after planting. The foliar fertilizers (Boost extra) frequency of applications was modified to avoid leaf injury. However, the recommended rate (4 L ha^{-1}) by the producers was considered, given 2.25 ml per plant^{-1}. It was applied at two weeks intervals from R1 – R4, corresponding to 20 % NPK, 1.5 % MgO, 0.15 %, 0.075 % Mn, Fe and Zn respectively and 0.0012 % Co and Mo.

Experimental design

The experiment was laid as a Randomized Complete Block Design (RCBD) with sixteen treatments replicated three times.

Statistical analysis

Data obtained from the trial was analyzed with GenStat 9th edition (2007), using analysis of variance (ANOVA). The various levels of significance (5 %) and means were separated using Duncan Multiple Range Test (DMRT). The count data were transformed (Log) before running the analysis where necessary.

RESULTS AND DISCUSSION

It was evident from this study that early-season vigorous growth needed for soybean development to boost grain production in the study area requires some level of soil amendments. Hence, the response of soybean to the initial N (25 kg N ha^{-1}) application could be attributed to the low nutrient soil status of the study area (Table 1). The MPN count of the indigenous rhizobia population at the study area was estimated as 5.12×10^1 cells g soil^{-1} (Adewoyin, 2014). More so research has recognized that initial nodulation takes time to develop and that significant N is not obtainable from N_2 – fixation until flowering begins. Similar to the findings in Alabama it was reported that N fertilization increased early-season soybean growth at five of seven locations however, the data were not conclusive. Also Wood et al. (1993) reported that starter-N appeared to offer the greatest benefit to early growth and plant-N content in sites where soybean growth responses were observed. Sawyer, (2001) also reported that: In some situations, pre-planting N application has increased soybean yield. Often it occurs in sites with low inorganic-N supply, low soil organic matter, low residual soil nitrate. He also observed that soybean sometimes appears N deficient early in the growing season (light green color, reduced growth or small leaves) especially with reduced and no-tillage. However, when either available soil N increases or N_2-fixation become more effective they recover.

Effect of Foliar fertilizer (BX), *Bradyrhizobium japonicum* (INO) and Nitrogen levels on soybean plant height and canopy spread

The application of at least 25 kg N ha^{-1} cannot be underestimated, better still the top dressing (25 kg N ha^{-1}) with INO or BX and the combination of the three (50 kg N ha^{-1}+INO+BX) gave a significant advantage to soybean plant height and canopy spread (Table 2). Meaning that indeed the application of N and foliar fertilizer (Beginning bloom) enhanced soybean growth thereby giving room for prolonged and effective photosynthetic activities required for optimum plant growth and maturity. The Control plot recorded the lowest plant height and canopy spread values in all and was at par in most cases with sole INO and BX. No wonder the response of soybean to Control, Inoculation and BX (plant height and canopy spread) was at par all through the experiment (Table 2) except for canopy spread response to BX which later picked up and eventually influenced the grain yield positively. Literature has reported that foliar fertilizer provides more rapid utilization of nutrients and permits the correction of observed deficiency symptoms in less time than would be required by soil application (Fageria et al., 2009). Soybean canopy spread response to the sole use of Inoculant was narrow until the peak of flowering and was immediately retarded, possibly due to leaf senescence; this confirms that there is a need for the additional nutrient supplement at this growth stage for soybean sustenance. Likewise, several reports have affirmed that the success of inoculation depends not only on high quality inoculants and good inoculation practices but also on the establishment of effective and efficient BNF through optimization of the factors that affect its performance such as legume genotype, climatic, edaphic and management factors.

Effect of foliar fertilizer (bx), inoculation and nitrogen levels on soybean growth

The response of soybean nodulation to applied treatments (Table 3) cannot be attributed to split application of N (50 and 75 kg N ha^{-1}) and foliar fertilizer because nodule assessment was done at soybean 50 % flowering, just before the top dressing of N and foliar fertilizer. Hence, nodule number for the treated plots and Control were significantly ($P<0.05$) at par, this agrees with several researchers who recommend N fertilization of soybean at small amounts at the early stage as a starter, especially in N deficient soils that improves growth and subsequently yield but may reduce nodulation (Osborne and Riedell, 2006; Pikul et al., 2001).

The inoculation of soybean with *Bradyrhizobium japonicum* inoculum with or without N and foliar fertilizer resulted in about 25 % and above nodule dry weight increase as against the Control. They are indicating that the introduced strains were compatible with the indigenous strains especially with the initial application of 25 kg N ha^{-1} thereby aggravated a substantial level of increase in dry nodule weight. Similarly, Emam et al. (2014) reported that the presence of N in the soil as a starter dose (60 kg per hectare) with a *Bradyrhizobium japonicum* bacteria positively affect nodule dry weight per plant and nitrogenase activity. Also Fatima et al. (2007) reported that nodule formation and its nitrogen fixation activity by *B. japonicum* are dependent on the presence of a compatible strain in the soil for a particular soybean variety. More so that the sole use of inoculation and Control plot revealed that soybean growth could not be sustained by inoculation only and the indigenous strains (Control) were not also effective in the study area. Likewise the biomass yield at 50 % flowering followed the same trend with the nodule weight hence, it can be induced that the combination of INO+25 kg N ha^{-1} enhanced the vegetative growth of soybean as was observed by some researchers. Gertenbach and Dugmore (2004) reported that crop biomass yield is affected by the same factors that affect crop yield. According to Adediran et al. (2015), N being an important constituent of nucleotides, proteins, chlorophyll and enzymes, is involved in various metabolic processes and has a direct impact on vegetative and reproductive phases of plants. Again the sole use of *Bradyrhiozobium japonicum* inoculum, sole foliar fertilizer (BX) and Control recorded the lowest biomass dry weight meaning that inoculation alone is not able to sustain soybean establishment and development, soybean also required some nutrients at the early growth stage before foliar fertilizer application began.

Pod formation could be explained with regards to all the used fertilizer sources, because the parameters were taken after top dressing of N and foliar fertilizer. The statistical mean value shows that the use of sole 25 kg N ha^{-1}, BX and their combinations (25 kg N ha^{-1}+BX) were positively responded to by inoculated soybean pod number and weight at the same level of significance, however the combinations with supplemented fertilizer application (50, 75 and BX) had slight increase of pod number and weight over the sole applications of the fertilizers used. Similarly, Lambon (2016) reported that the higher levels of N (45 kg N) produced ha^{-1} significantly higher pod numbers than 15 and 0 kg N in the same study area. This is similar to earlier research findings (Umeh et al., 2011; Diep et al., 2002; Chemining' wa et al., 2012).

Effect of foliar fertilizer (bx), *Brady rhizobium japonicum* and nitrogen levels on soybean grain yield and harvest characteristics

The similar trend of soybean pod number and pod weight responses observed due to N- levels as compared to the Control actually translated to grain yield. These are positive indications of soybean response to N fertilizer application, which is in line with the works of other researchers (Umeh et al., 2011; Diep et al., 2002). This also confirms an earlier report by Fageria et al. (1997) that legume grains yield is a function of a number of pods per plant.

The positive response of soybean to foliar fertilizer is an indication that the use of foliar fertilizer just has been reported by some researchers who have the tendency to enhance the growth and especially the grain yield of soybean. This possibly could lend credence to the fact that the foliar fertilizer contains some level of micro and macronutrients that could have been made available to the plant as at when needed. Fageria et al. (2009) reported that foliar fertilizer supplement soil fertilization because nutrients penetrate the cuticle of the leaf or the stomata and then into the cells more readily. Furthermore, to reduce fertilizer application to soil, new formulations of foliar fertilizer (micro- or macro-nutrients or both) are available worldwide and could be more effective than soil-applied fertilizer in reducing the effect of nutrient deficiencies on BNF (Zahran, 1999). In this study the highest grain yield recorded on 50 Kg N ha^{-1}+BX plot gave 93 % significant increase over Control, similarly, Lambon (2016) reported that 45 kg N yielded the highest grain of 2146 kg ha^{-1}, however the application of 50 kg N ha^{-1}+BX and INO+50 kg N ha^{-1} in the same year and study area gave (3587 and 3172 kg ha^{-1} respectively) 67 % and 48 % increase in grain yield over Lambon's report complementing Mallarino et al. (2001) report which says that the effect of foliar fertilization on grain yield depends on the application period of the different growth stages of soybean. Meaning that indeed the fertilizer added at beginning bloom till the early podding stage of soybean development complemented and sustained soybean through a reproductive stage (when the nodules are assumed to have ruptured) for efficient pod formation and seed filling. The treated plots were positively responded to by soybean seed weight (HSW), husk and haulm weight in a similar trend as compared to the control (Table 4) which recorded the lowest weight in all, meaning that the soil if not amended with fertilizer will hinder the performance of soybean in the study area.

CONCLUSION

The use of various sources of fertilizer, indeed contributed positively to the performance of soybean in the study area, Response of soybean growth and yield to the various fertilizer combinations leaves the farmer with a whole lot of choice to make depending on his financial capability to purchase the required fertilizer. It was glaring that inoculated soybean indeed requires complementary application of fertilizer at beginning bloom – early pod filling stage, however, the highest produced treatment (50 kg N ha^{-1}+BX) performed significantly at par with some of the other treated plots such as the other levels of N+BX, the INO +N-levels, the INO+ N-levels+BX and even some sole application of fertilizer. However, the highest grain yielded plot (50 kg N ha^{-1}+BX) recorded close to 100 % grain yield increase over the Control. While the use of sole BX and combination of INO+25 kg N ha^{-1}, INO+BX and INO+25 kg N ha^{-1}+BX recorded at least 60, 59, 47 and 50 % grain yield increase over Control respectively, hence can also be adopted depending on the farmers choice.

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Table 1. Soil physical and chemical properties and MPN count of the experimental site

Soil properties	Value
pH (1:2.5 H_2O)	5.5
Organic carbon (%)	0.9
Total N (g kg^{-1})	0.5
Extractable P (mg kg^{-1})	5.7
Ca (C mol kg^{-1})	2.30
Mg (C mol kg^{-1})	0.71
K (C mol kg^{-1})	0.06
Na (C mol kg^{-1})	0.08
Mn (mg kg^{-1})	4.09
Cu (mg kg^{-1})	9.02
Fe (mg kg^{-1})	19.00
Exchangeable acidity (C mol kg^{-1})	0.73
Sand (%)	68
Silt (%)	24
Clay (%)	8
Texture	Sandy loam
MPN (cell g^{-1} soil)	5.12×10^1

Table 2: Effect of Foliar fertilizer (BX), *Bradyrhizobium japonicum* (INO) and Nitrogen levels on soybean growth parameters

	Plant height (cm)					Canopy spread (cm)				
	WAP					WAP				
Treatment	6	8	10	12	14	6	8	10	12	14
25 (kg N ha^{-1})	31.60ab	48.47abc	57.97ab	597.7ab	638.3ab	49.67ab	52.22abc	67.13bcde	338.0abcd	325.0cde
50 (kg N ha^{-1})	29.80ab	47.40bc	60.33a	613.7ab	629.0ab	46.67bcd	50.94abc	73.73ab	390.0a	396.7a
75 (kg N ha^{-1})	29.77ab	49.23abc	53.80abc	555.3b	615.7ab	50.73ab	51.00abc	63.07e	326.7bcde	332.7bcde
BX	23.23c	37.67e	48.27bcd	413.0d	464.0d	41.47e	43.00de	69.27abcde	341.7abcd	352.0abcd
INO	22.80c	37.23e	41.70d	449.0cd	506.3cd	42.00cde	40.74e	70.73abcd	294.0de	309.0de
INO+25	29.45b	46.57cd	54.77ab	556.0b	604.3ab	47.80ab	48.00bcde	67.07bcde	306.7cde	333.7bcde
INO+50	32.57ab	52.40abc	62.87a	643.0ab	668.3ab	51.27ab	56.17a	76.73a	374.0ab	379.7 ab
INO+75	30.43ab	52.00abc	57.67ab	602.7ab	659.3ab	49.40ab	53.94ab	72.47abc	370.7ab	368.0ab
INO+BX	22.82c	37.13e	47.40bcd	413.0d	464.3d	39.80e	45.00cde	65.47cde	332.3abcd	332.0bcde
25+BX	30.67ab	48.37abc	54.13abc	549.3bc	592.7bc	50.47ab	48.61bcd	69.87abcde	342.0abcd	350.7abcd
50+BX	33.38a	54.00a	65.10a	659.3a	691.3a	49.07ab	56.78a	70.80abcd	345.0abcd	354.3abcd
75+BX	30.77ab	51.10abc	54.97ab	545.7bc	656.3ab	49.60ab	52.44ab	68.47bcde	340.3abcd	349.0abcd
INO+25+BX	32.00ab	50.33abc	60.07a	614.7ab	670.3ab	51.13ab	53.33ab	72.13abc	364.3abc	371.7ab
INO+50+BX	30.88ab	50.03abc	60.70a	623.3ab	656.7ab	48.40ab	52.61ab	67.20bcde	349.3abcd	355.0abcd
INO+75+BX	31.07ab	53.50ab	58.57ab	607.7ab	682.0ab	53.20a	54.00ab	70.80abcd	356.0abc	367.0ab
CONTROL	24.72c	40.00de	42.97cd	430.7d	472.0d	42.80cde	43.11de	64.53de	272.3e	290.3e
%CV	7.6	8.4	12.6	10.9	9.6	6.3	8.8	6.5	10.4	9.1

Means followed by the same letter (s) within each column are not significantly different at $p \leq 0.05$

Table 3: Effect of Foliar fertilizer (BX), *Bradyrhizobium japonicum* and Nitrogen levels on soybean growth parameters

Treatment	Nod number plant^{-1}	Nod weight (mg plant^{-1})	Biomass weight (kg ha^{-1})	Pod number plant^{-1}	Pod weight (g plant^{-1})
25(Kg N ha^{-1})	1.98ab	570.0b	3190 bcd	2.87abc	22.22abc
50 (Kg N ha^{-1})	2.06ab	523.3b	3089 bcd	2.67d	13.73cd
75 (Kg N ha^{-1})	1.86b	430.0b	3778 ab	2.63d	15.08cd
BX	1.92ab	476.7b	2196 d	2.80abcd	23.17abc
INO	2.26ab	800.0ab	1866 d	2.77abcd	18.35bcd
INO+25	2.29ab	796.7ab	3618 abc	2.73bcd	17.42bcd
INO+50	2.18ab	760.0ab	3902 ab	2.70cd	17.15bcd
INO+75	2.35ab	1070.0a	4556 a	2.90ab	25.44ab
INO+BX	2.33ab	796.7ab	2418 cd	2.90ab	25.97ab
25+BX	1.83b	510.0b	3666 abc	2.73bcd	22.47abc
50+BX	2.12ab	543.3b	3711 abc	2.73bcd	17.49bcd
75+BX	1.96ab	553.3b	3727 abc	2.73bcd	18.87bcd
INO+25+BX	2.27ab	866.7ab	4580 a	2.77abcd	20.28abcd
INO+50+BX	2.23ab	576.7b	3903 ab	2.93a	29.23a
INO+75+BX	2.44a	883.3ab	4613 a	2.93a	30.23a
CONTROL	1.98ab	606.7ab	2449 cd	2.50d	11.86d
%CV	15.1	30	23	4.2	29.8

Means followed by the same letter (s) within each column are not significantly different at $p \leq 0.05$

Table 4: Effect of Foliar fertilizer (BX), *Bradyrhizobium japonicum* and Nitrogen on soybean grain yield and harvest

Treatment	Grain yield (kg ha^{-1})	HSW	Husk weight (g plant^{-1})	Haulm weight (g plant^{-1})
25 (kg N ha^{-1})	2486abc	15.07a	7.46abc	8.19bcd
50 (Kg N ha^{-1})	2738abc	13.63ab	6.14abc	5.72cd
75 (Kg N ha^{-1})	2419bc	13.30b	6.45abc	6.73cd
BX	2969abc	13.87ab	8.28abc	5.82cd
INO	1979c	13.60ab	7.42abc	4.85cd
INO+25	2940abc	14.30ab	6.14abc	8.09bcd
INO+50	3172ab	13.50ab	6.16abc	7.22bcd
INO+75	2390bc	13.83ab	9.42ab	9.25abc
INO+BX	2729abc	14.07ab	9.39ab	6.93bcd
25+BX	2462abc	14.60ab	8.48abc	7.28bcd
50+BX	3587a	13.27b	7.09abc	6.56cd
75+BX	3214ab	14.43ab	5.66bc	6.85cd
INO+25+BX	2772abc	13.67ab	7.11abc	5.95cd
INO+50+BX	2525abc	14.00ab	9.93a	12.76a
INO+75+BX	3429ab	14.13ab	7.85abc	11.37ab
CONTROL	1853c	13.70ab	4.55c	4.53d
%CV	25.7	6.9	29.7	27.5

Means followed by the same letter (s) within each column are not significantly different at P≤0.05