ICAAT 2019

FOOD INSECURITY IN AFRICA:
AGRICULTURAL DIVERSIFICATION AS A PANACEA

Proceedings of

1st

International Conference of Agriculture and Agricultural Technology
{ICAAT 2019}

VENUE: Federal University of Technology, Minna
School of Agriculture and Agricultural Technology

DATE: 23rd - 26th April, 2019

- Dr. C. E. Chinma
- Mr. A. Ibrahim
- Prof. J. N. Nmadu
- Dr. O. J. Ajayi
- Prof. S. O. E. Sadiku
- Prof. R. S. Olaleye
- Prof. A. S. Gana
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SCHOOL OF AGRICULTURE AND AGRICULTURE TECHNOLOGY

The School of Agriculture and Agriculture Technology was established in January 1986 with two Departments (Animal Production and Crop Production) and four pioneer academic staff (Dr. Z. Stecki, Dr. S. Plonka, Mr. E. K. Tsado and Mr S. L. Lamai). With subsequent development, four more departments (Soil Science and Land Management, Water Resources, Aquaculture and Fisheries Technology and Agricultural Economics and Farm Management and Agricultural Extension and Rural Development) were created.

The Department of Soil Science started as a Unit under the Department of Crop Production in1987 and attained full status as a Department in 1988 and name was changed to Department of Soil Science and Land Management. The Department of Fisheries Technology, now known as Department of Water Resources, Aquaculture and Fisheries Technology started in 1987 as a Unit in the department of Animal Production which transformed to the Department of Animal Production and Fisheries Technology in 1989 and was split into department of Animal Production and Department of Fisheries Technology in 1991. The Department was repackaged and renamed Department of Water Resources, Aquaculture and Fisheries Technology in 2006. A new Unit, Agricultural Economics and Extension Technology was created during the 1997/1998 section under the Department of Crop Production. The Unit was separated from the mother Department and upgraded to a full-fledge Department in 2002. Approval has also been given for creation of Department of Agricultural Extension and Rural Development while the mother

Department will henceforth bear Department of Agricultural Economics and Farm Management.

In 1997, the proposed Department of Food Science and Nutrition took off as a Unit in the Department of Animal Production and became a full-fledged Department of Food Science and Technology. Similarly, the Horticulture unit has emerged in the Department of Crop Production and it is hoped that, in due course, a separate Department of Horticulture will be created.

The student intake into the School at inception in 1986 stood at two (one student each for Department Of Animal Production and Department Of Crop Production), and these graduated in 1989. Since then, the school has witness tremendous progress in terms of staff recruitment and development, infrastructural development and student enrolment. Today, the staff and student population stand at 107 and 1,444 respectively.

Dr. Z. Stecki was the first Coordinator for the school (1986 September 1988). Dr. E.A. Salako took over as School Coordinator from October 1988 to 1990 and served later as Acting Dean until he became the only Professor in the School when he was made the Dean. After his tenure, the School reverted to the position of Acting Deanship since no Professor was on ground then. These were Dr. J.A. Oladiran (1995-1998) and Dr. S.L. Lamai (1998-2001). By September 2001, with more Professors on ground portraying the extent of development, the Board of School Of Agriculture And Agricultural Technology, in accordance with the University regulations, elected Prof.O.O.A. Fasanya as the Dean of the School for a two-year term. Since then, the Deanship position in the School has been filled by election. Prof. E.A. Salako took over from Prof O.O. A. Fasanya in 2003 and Prof. S.L. Lamai took over from Prof. E.A. Salako in 2005. In January 2008, following the appointment of Prof. S.L. Lami as the dean of postgraduate school, Prof. K.M. Baba assumed Deanship of the School. In February 2012, Prof. M.G.M. Kolo succeeded Prof. K.M. Baba who had completed his second two-year term. Professor Kolo was re-elected another term of two years from February, 2014. While servicing the second term, he was appointed Dean of Postgraduate School which necessitated another election leading to the emergence of Prof. R.J. Kolo the new Dean in March 2015. Following the completion of the second term of Prof. Kolo, elections were conducted and Prof. A. J. Odofin emerged as the Dean as from 9th of April, 2019.

INTERNATIONAL CONFERENCE OF AGRICULTURE AND AGRICULTURAL TECHNOLOGY

The Committee of the 1st International Conference of Agriculture and Agricultural Technology (ICAAT 2018) is pleased to announce the conference. This conference is an avenue to disseminate innovative research results and latest development in technologies related to agriculture which are aimed at fighting food insecurity. The conference will bring together leading researchers and scientists in agriculture and allied fields, and even commoners in the domain of interest from around Africa and the world. This international conference brings together experts, intelligentsia and potential researchers from various fields of agriculture to cross-fertilize ideas and ponder on the recent innovations and techniques for the sustainable development aimed at fighting food insecurity in Africa. Therefore, during the three-day conference, all participants will have plenty of opportunities for exchanging ideas, findings and the latest research results and exploring the rich culture of the Nupe and Gbagyi kingdoms in central Nigeria.

PROGRAMME OF ACTIVITIES

DAY 1: TUESDAY, APRIL 23			
Time	**Activity**		
7.00-6pm	Arrival		
DAY TWO: WEDNESDAY, APRIL 24			
8.00 am-	Registration of Participants		
8.00 -9.00	BREAKFAST		
9.00-11.00	**PLENARY SESSION** Paper 1 Seed yield and physiological seed quality of cowpea varieties sown at different planting dates in Minna, Southern Guinea Savanna of Nigeria by Mrs. O.A. Adediran Paper 2 Performance of soybean genotypes under *Rhizobia* inoculation across three Agro ecologies of Nigeria by Dr. K.D. Tolorunse		
11.00-1.00	**TECHNICAL SESSION 1**		
	Hall 1 Prof. A.S. Gana (Chairman) Dr. B. A. Alimi (Rapporteur) Abstract no.: 1,2,3,4,5,6,7,8,9,10	**Hall 2** Prof. E.K. Tsado (Chairman) Dr. E. Daniya (Rapporteur) Abstract no.: 11,12, 15,16,17,18,19,20,21,90	**Hall 3** Prof. K.M.Baba (Chairman) Dr. O. J. Alabi (Rapporteur) Abstract no.: 22,23, 25,26,27,28,29,31, 76, 103
1.00-2.00	**BREAK/LUNCH**		
2.00-3.30	**TECHNICAL SESSION 2**		
	Hall1 Prof. S.O.E. Sadiku (Chairman) Dr. S.S.A.Egena (Rapporteur) Abstract no: 32 ,35,36,37,38,39,40,41,42, 75	**Hall 2** Prof. A. Aremu (Chairman) Dr. C.O.Adebayo (Rapporteur) Abstract no: 43,44,45,47,48,49,50,51,52, 104	**Hall 3** Prof. B.A.Ayanwale (Chairman) Dr. M. Ibrahim (Rapporteur) Abstract no: 53,54,55,56,57,59,60,61,62, 102
DAY THREE: THURSDAY, APRIL 25			
8.00-9.00	BREAKFAST		
8.00-10.00	Arrival of Guests and Dignitaries		
10.00-10.15	National Anthem/Prayer		
10.15-10.30	Introduction of Guests		

10.30-10.45	Opening Address by Chairman of the Occasion		
10.45-11.15	Keynote Address		
11.15-12.00	Goodwill Messages		
12.00-1.30 Break/Lunch			
1.30-3.00		TECHNICAL SESSION	
	Hall 1 Prof. R.S. Olaleye(Chairman) Dr. E.Z. Jiya (Rapporteur) Abstract no: 30, 33 46, 65,66,67,68,69,70,71,72,73,74	**Hall 2** Prof. A.T. Ijaiya (Chairman) Dr. A.A.A. Coker (Rapporteur) Abstract no:77,78, 79,80,81,82, 83,84,85,86,87,88,89	**Hall 3** Prof. J.O.Oyero (Chairman) Dr. K.D. Tolorunse (Rapporteur) Abstract no: 24,91,92,93,94,95,96,97,98, 99,100,101
3.00-4.15	Communique and Formal closing		
4.30 – 6.00	Cocktail		

COMMUNIQUE ISSUED AT THE END OF THE 1ST INTERNATIONAL CONFERENCE OF AGRICULTURE AND AGRICULTURAL TECHNOLOGY (ICAAT) HOSTED BY SCHOOL OF AGRICULTURE AND AGRICULTURAL TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE, NIGERIA BETWEEN 23RD-26TH APRIL, 2019.

PREAMBLE

The conference with the theme: "Food Insecurity in Africa: Agricultural Diversification as Panacea" had over one hundred and seventy (170+) participants from all over the world. The conference had a total submission of one hundred and four (104) papers presented in two plenary and 12 technical sessions. The conference was declared open by the Vice Chancellor of the Federal University of Technology, Minna, Professor Abdullahi Bala. The lead paper on the theme of the conference was presented by Professor David Norris, Vice Chancellor of the University of Botswana.

The conference identified food insecurity as a major challenge to improved livelihood for the people of Africa. According to Food and Agriculture Organization (FAO), thirty nine (39) countries in the world were experiencing food emergencies in 2006, twenty five (25) of the countries were in Africa. The recent developments in the region such as climate change, insurgencies, and conflicts are further aggravating the situation. Hence, the conference had robust deliberations which identified key issues affecting food insecurity in the continent and brought forward practical solutions to address the challenges through agricultural diversification. The contributions of agriculture to food security, which could eventually transform to economic growth for the continent are summarized under five inter-sectorial linkages. Thus: Supply of food for both domestic consumption and export; provision of markets; increased domestic savings; foreign exchange earnings; and employment of labor.

The highlights of resolutions are listed as follows:

African governments are advised to invest in infrastructural development at the rural areas where the main agricultural activities take place.

The governments are encouraged to cut down on the huge amounts of money in foreign currency being spent on subsidizing food imports to encourage local food production.

It is the right time to diversify the economy from oil based to agricultural driven, which seems to be the most sustainable way forward.

There is need for agricultural transformation through mechanization and utilization of appropriate technologies

Small scale farmers should be encouraged to form cooperatives to enable them assess government and non-governmental assistance for increased productivity.

Governments are advised to comply with Maputo/Malabo Declaration of 10% national annual budget for agriculture

Academics are challenged to undertake comprehensive researches to provide fundamental solutions to lingering herders-farmers conflict which has led to great reduction in agricultural productivity and claimed several lives, especially in Nigeria.

African leaders are advised to deploy utmost political will, which is essential for achieving food security in the continent.

Conclusively, stakeholders are implored to focus more on agriculture because it is extremely important, highly sustainable, but under-explored.

Professor J. N. Nmadu
(Chairman, LOC)

Dr. O. J. Ajayi
(Secretary, LOC)

Communique Committee

Dr. J. H. Tsado
Chairman,

Dr. B. A. Alimi
Secretary

Dr. D. N. Tsado
Member

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INFLUENCE OF MINERAL NITROGEN-LEVELS AND FOLIAR FERTILIZER ON INOCULATED SOYBEAN NODULATION, GROWTH AND YIELD

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ABSTRACT

The need for N in Soybean production has been confirmed by so many reseachers; however the need for nutrient supplement at leaf senescence stage to sustain successful seed formation, pod filling and quality seed harvest has not really been reported in the Northern region of Ghana. The influence of N rate and time of application on soybean cultivation has also aggravated a lot of research questions. Therefore, an experiment was conducted to evaluate the response of soybean plant height, canopy spread, nodulation, pod formation and grain yield to mineral fertilizer (30 kg P_2O_5 and K_2O each as basal application) with ammonium sulphate as starter N (25kg Nha^{-1}), then a top dressing (25 or 50kg Nha^{-1}) at mid-vegetative stage, foliar fertilizer (Boost xtra 4 litre ha^{-1}, at vegetative/early podding stage) and 5 g $seed^{-1}$ of *Bradyrhizobium japonicum* inoculant. The experiment was a Randomized Complete Block Design replicated three times. The results obtained shows that the appropriate timing of N and foliar fertilization could enhance soybean growth and grain yield. Plant height and canopy spread response to the application of initial 25kg Nha^{-1} was an indication that a minimum level of N is a necessity for soybean establishment. Also soybean pod formation and seed grain were all proofs of significant ($P<0.05$) influence of the applied treatments on soybean development as compared to the Control. Infact, an impressive grain yield (94% increase) was produced from the plot treated with 50kg Nha^{-1}+BX compared to Control. However, the lowest N-level (25kg Nha^{-1}) used as sole and better still it's combinations with BX or INO and the combination of the three (25kg Nha^{-1}+INO+BX) also gave substantial increase of 50% and above grain yield over the Control. Hence, the use of fertilizer (mineral, foliar and bio-fertilizer) is paramount in augmenting soybean production in the study area. The choice, rate and time of application depend on the farmer's financial capability.

KEY WORD: Soybean, Canopy spread, *Bradyrhizobium japonicum*, Scenecense, Boost xtra

INTRODUCTION

Nitrogen (N) and foliar fertilization are not traditional nutrient management practices for soybean production. Because soybean as a legume plant is expected to obtain adequate N through mineral N assimilation and symbiotic N_2 fixation (Hartwig, 1974). But because of soybean high N requirement farmers have difficulty in satisfying its N demands. Hence, mineral N fertilization is a crucial factor in oil seed legume production as reported by 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 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 (E.-Adewoyin, 2014). Few studies have evaluated the effect of Nitrogen (25kg Nha^{-1}), its top dressing (25kg Nha^{-1} and 50kg Nha^{-1}) at mid–vegetative stage and foliar fertilizer (macro and micro nutrients) application at mid-vegetative to early podding stage 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). Peoples *et al*. (1995) reported that inoculation can lead to the establishment of large populations of rhizobia in the rhizosphere and improve nodulation and N_2 - fixation. However soybean response to inoculation is dependent on so many factors including the inherent field variability and differences in environmental and edaphic conditions (van Kessel and Hartley, 2000). Thies *et al.* (1991) reported that 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. In general, and as confirmed by Araujo *et al*. (1994), the effective and efficient use of inoculation occur in soils which are depleted or contain low indigenous rhizobia population and when there is an established but inefficient rhizobia population. Dorivar *et al*. (2009) reported a positive response of rhizobia inoculation to nodulation, shoot biomass and grain yield while Otieno *et al*. (2009) reported increased nodule number, nodule dry weight but not shoot biomass, root dry weight and grain yield. These variations in response to inoculation could be due to many factors including soil pH, temperature, moisture content and soil nutrient status (especially N).

Soybean flowering phase is followed by pod formation, leaf senescence and seed filling**.** The peak of flowering is the peak of nodule activities (BNF) after which the nodules rupture and 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). Garcia and Hanway (1976) reported yield increases of 27 to 31% when liquid N – P – K - S fertilizer was applied at late reproductive stages (R5 to R6). Wesley *et al*. (1998) and Mallarino *et al*. (2001) also reported an increase in yield due to the use of foliar fertilizer. On the contrary, Boote *et al*. (1978) and Parker and Boswell (1980) reported neither increase nor decrease in yield of soybean to the use of foliar fertilizer. While, Clement *et al*. (2013) reported that the application of foliar micronutrients on the double inoculation of fungi - Rhizobium increased grain yield. Similarly, Ross *et al*. (2006) and Bellaloui *et al*. (2010) indicated the importance of some micronutrients such as boron on soybean nitrogen fixation and seed yield. Due to all this controversial reports there is need to investigate the response of inoculated soybean to N fertilizer levels (split application) and foliar fertilizer (boost xtra) especially in the Northern region of Ghana.

1.1 Objective

To evaluate the effectiveness of Foliar fertilizer (Boost xtra), Mineral nitrogen levels and *Bradyrhizobium japonicum* inoculation on nodulation, growth and yield of soybean.

2.0 Materials and Methods

2.1 Experimental site

This experiment was carried out at the experimental field of Savanna Agricultural Research Institute, Nyampala, 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 mono - modal (April / May – October), and a dry season with severe harmmattan wind 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 Tingoli series classified as Ferric Luvisol (FAO 1988).

2.2 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 augur. Samples were then air dried, thoroughly mixed and passed through a 2 mm mesh sieve and packaged for laboratory analyses.

2.3 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 as described by Helmke and Sparks (1996). Exchangeable bases (Ca^{2+}, Mg^{2+} K^{+}, Na^{+}) was determined using 1N NH_4OAC extract method (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 titremetric 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) grammes air dried soil was weighed into separate plastic bottles for Cu, Fe and Mn after which hundred milliliters DPTA extract was added to each. It was shaken for 2 hours and filtered with Whatman No. 42 filter paper. Their values were all read on an Atomic Absorption Spectrophotometer using the appropriate standards. Soil physical properties was also determined using Bouyoucous hydrometric method (Bouyoucous, 1962).

2.4 Most Probable Number method (MPN)

The estimation of the rhizobia populations in the study fields were carried out using the most probable number method (MPN) (Vincent, 1970). Uniform seeds of good viability were surfaced sterilized with alcohol and hydrogen peroxide as described by

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.

Five – fold dilutions of each of the samples were made as follows: Five different test tubes were filled with 20ml distilled water. With a pipette, 5ml solution was transferred from the 10^{-1} dilution (which was prepared by vigorously shaking 100g of the sample in 400ml of the sterile distilled water) into one of the five different test tubes. Series of dilutions were then made from 10^{-1} to finally achieve 10^{-6}. 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)

2.4 Land preparation and layout

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

2.5 Inoculation

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

2.6 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 in June 2012 starting with the un-inoculated plots followed by the inoculated plots to avoid contamination.

2.7 Treatments

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

2.8 Fertilizer application

Nitrogen was applied as ammonium sulphate. The 50 and 75kg Nha^{-1} treatments were applied in two splits; 25kg Nha^{-1} was applied seven days after planting and top dressed at 50% flowering with 25 and 50kg Nha^{-1} (to give 50 and 75 kg Nha^{-1}) respectively. Triple super phosphate and Muriate of potash were applied basally (30kg ha^{-1} each) seven days after planting. The foliar fertilizers (Boost Xtra) frequency of applications was modified to avoid leaf injury. However, the recommended rate (4L ha^{-1}) by the producers was considered, given 2.25ml per $plant^{-1}$. It was applied at two weeks intervals from 50% flowering (6^{th} week) to early podding stage (4 times) corresponding to 20% NPK, 1.5% MgO, 0.15%, 0.075% Mn, Fe and Zn, 0.0012% Co and Mo.

2.9 Experimental design

Each treatment plot of 7 × $7m^2$ was made of nine rows with 2 m between plots. The experiment was laid as Randomized Complete Block Design (RCBD) with sixteen treatments replicated three times.

2.10 Statistical analysis

Data obtained from the trial was analyzed with GenStat 9^{th} 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.

3.0 Results

3.1 Soil physical and chemical properties and MPN count of the indigenous rhizobia

The soil of the experimental site was slightly acidic and low in all soil nutrients measured (Table 1). The organic carbon (< 20 g kg^{-1}), total nitrogen (< 1 g kg^{-1}), exchangeable cations (< 5 C mol kg^{-1}), effective cation exchange capacity (< 5 C mol kg^{-1}) and extractable P (< 10 mg kg^{-1}) were low. The MPN count of indigenous rhizobia population at the study area was estimated as 5.12×10^1 cells g $soil^{-1}$ (E.-Adewoyin, 2014).

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
(C mol kg^{-1})	0.06
Na (C mol kg^{-}	0.08
^{1}) Mn (mg kg^{-}	4.09
^{1}) Cu (mg kg^{-1})	9.02
Fe (mg kg^{-1})	19.00
Exchangeable acidity (C mol kg^{-}	0.73
^{1}) Sand (%)	68
Silt (%)	24
Clay (%)	8
Texture	Sandy loam
MPN (cell g^{-1} soil)	5.12×10^{1}

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

Soybean plant height and canopy spread result was as shown on Table 2. The application of 50kg Nha^{-1}+BX resulted in the highest plant height which ranged from 33.38 – 691.3cm (6-14th WAP). At 6WAP the tallest plant gotten from the application of 50kg Nha^{-1}+BX was at par with the other treated plots except for INO+25kg Nha^{-1}, INO+BX, sole BX, sole INO and Control. The combination of the different fertilizers used (INO, N-levels and BX) aided plant height increase all through the experiment, ranging from 29.45 – 691.3cm $plant^{-1}$ (6-14WAP), except INO+BX which was at par with Control. Soybean canopy spread was enhanced with the application of INO+75kg Nha^{-1}+BX (53.00cm) at 6WAP, though significantly at par with other treated plots except; sole BX, INO+BX, sole INO and Control. At 8WAP the application of 50kg Nha^{-1}+BX and INO+50kg Nha^{-1} recorded the widest canopy spread of 56.78 and 56.17cm respectively (Table 2), however not significantly ($p>0.05$) different from other treated plots, while sole BX, INO+BX, sole INO and Control still recorded narrow canopy spread similar to the trend observed for plant height. At 10-14WAP the various fertilizers used as sole and the various combinations in two's or three's (INO, N-levels and BX) maintained high canopy spread while sole application of INO and Control recorded the lowest value all through.

Table 2: Effect of Foliar fertilizer (BX), *Bradyrhizobium japonicum* (INO) and Nitrogen levels on soybeanICAAT 2019**growth parameters**

	Plant height (cm)					Canopy spread (cm)				
	WAP					WAP				
Treatment (kg Nha^{-1})	**6**	**8**	**10**	**12**	**14**	**6**	**8**	**10**	**12**	**14**
25	31.60ab	48.47abc	57.97ab	597.7ab	638.3ab	49.67ab	52.22abc	67.13bcde	338.0abcd	325.0cde
50	29.80ab	47.40bc	60.33a	613.7ab	629.0ab	46.67bcd	50.94abc	73.73ab	390.0a	396.7a
75	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

3.3. Effect of Foliar fertilizer (BX), Inoculation and Nitrogen levels on soybean growth

The application of INO+75kg Nha^{-1}+BX resulted in the highest nodule number though not significantly (P>0.05) different from nodule gotten from other treated plots and the control except for 75kg Nha^{-1} and 25kg Nha^{-1}+BX) . The highest nodule dry weight was recorded from plot treated with INO+75kg Nha^{-1} (1070 mg $plant^{-1}$), followed by the application of INO+75kg Nha^{-1}+BX, INO+25kg Nha^{-1}+BX and sole Inoculation. Also the highest biomass weight was recorded from plot treated with INO+75kg Nha^{-1}+BX (4613 kg ha^{-1}) followed by INO+25kg Nha^{-1}+BX and INO+75kg Nha^{-1} (4580 and 4556 kg ha^{-1}) respectively, and were significantly at par with biomass from all other plots with treatment combinations except for INO+BX (2418 kg ha^{-1}). The use of sole INO, BX and Control performed at par with sole application of all the treatments used. Similarly the application of INO+75kg Nha^{-1}+BX and INO+50kg Nha^{-1}+BX gave the highest pod number (2.93 $plant^{-1}$) each, which were not significantly different from the values gotten from the treatment combinations with the lowest level of N (INO+25kg Nha^{-1}+BX), sole 25kg Nha^{-1}, BX, INO, INO+BX and INO+75kg Nha^{-1} (Table 3). The control recorded the lowest pod number (2.50 $plant^{-1}$). In the same trend the highest pod weight was recorded from plots treated with INO+75kg Nha^{-1}+BX, followed by INO+50kg Nha^{-1}+BX, however, were at par with INO+BX, INO+75kg Nha^{-1}, 25kg Nha $^{-1}$+BX, 25kg Nha^{-1} and INO+25kg Nha^{-1}+BX while the Control recorded the lowest pod weight in all (11.86 $plant^{-1}$).

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

Treatment (Kg N ha^{-1})	Nod number $plant^{-1}$	Nod weight (mg $plant^{-1}$)	Biomass weight (kg ha^{-1})	Pod number tran $plant^{-1}$	Pod weight (g $plant^{-1}$)
25	1.98ab	570.0b	3190 bcd	2.87abc	22.22abc
50	2.06ab	523.3b	3089 bcd	2.67d	13.73cd
75	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

4.4. Effect of foliar fertilizer (BX), *Bradyrhizobium japonicum* and Nitrogen levels on soybean grain yield and harvest characteristics

The highest grain yield of 3587 kg ha^{-1} was recorded from the plot treated with 50kg Nha^{-1}+BX, followed by INO+75kg Nha^{-1}+BX, 75kg Nha^{-1}+BX, INO+50kg Nha^{-1}, BX, INO+25kg Nha^{-1}, INO+25kg Nha^{-1}+BX, 50kg Nha $^{-1}$ and INO+BX . With values ranging from 2729 – 3429 kg ha^{-1} over the control (1853kg ha^{-1}) which was at par with sole INO (1979kg ha^{-1}). The highest hundred seed weight (HSW) was recorded on plots treated with 25kg Nha^{-1}, though at par with most treated plots, the control had the lowest HSW value in all (Table 4). The soybean haulm weight was highest on plots treated with INO+50kg Nha^{-1}+BX (12.76 g plant^{-1}) followed by INO+75kg Nha^{-1}+BX (11.37 g plant^{-1}) and INO+75kg Nha^{-1} (9.25 g plant^{-1}) while Control recorded the lowest value (4.53 g plant^{-1}). Soybean husk weight was highest on plots with INO+50kg Nha^{-1}+BX (9.93 g plant^{-1}) followed by INO+75kg Nha^{-1} (9.42 g plant^{-1}) and INO+BX (9.39 g plant^{-1}), though not significantly different from values recorded from other treated plots, again the Control had the lowest husk weight of 4.55 g plant^{-1}.

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

Treatment (kg Nha^{-1})	Grain yield (kg ha^{-1})	HSW	Husk weight (g plant^{-1})	Haulm weight (g plant^{-1})
25	2486abc	15.07a	7.46abc	8.19bcd
50	2738abc	13.63ab	6.14abc	5.72cd
75	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

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 amendment. The application of at least 25kg Nha^{-1} cannot be underestimated, better still the top dressing (50kg Nha^{-1}) with INO or BX and the combination of the three (50kg Nha^{-1}+INO+BX) gave significant advantage to soybean plant height and canopy spread (Table 2). Meaning that indeed the mid vegetative application of N and foliar fertilizer enhanced soybean growth thereby giving room for prolonged and effective photosynthetic activities required for optimum plant growth and maturity. The response of soybean to the initial N application could be attributed to the low nutrient soil status of the study area (Table 1). 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, preplanting 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 appear 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 becomes more effective they recover. 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) were at par all through the experiment (Table 2) except for canopy spread response to BX which later picked up at the 10 to 14th weeks and eventually positively influenced the grain yield. Literature have 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). Contrary to soybean canopy spread response to sole use of Inoculant which was narrow until the peak of flowering (10th week) and was almost immediately retarded again possibly due to leaf senescence, which confirms that there is need for 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 (Giller, 2001; Giller and Wilson, 1991; Sanginga *et al*., 1995). Response of soybean nodulation to applied treatments (Table 3) cannot be attributed to split application of N (50 and 75kg Nha^{-1}) and foliar fertilizer because nodule assessment was done at soybean 50% flowering, just before the split application of N and foliar fertilizer. The nodule number for the treated plots and Control were significantly ($P<0.05$) at par, this agrees with several workers 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).

After all controversial reports about the negative and positive effects of N fertilizer use on soybean nodulation has been affirmed especially with high level of N use. This study support the use of 25kg Nha^{-1} as it was observed to be sufficient for inoculated soybean successful germination and establishment in the study area. Similarly, Emam *et al*., 2014 reported that the presence of N in the soil as a starter dose (60kg per hectare) with a *Bradyrhizobium japonicum* bacteria positively affect nodule dry weight per plant and nitrogenase activity. The inoculation of soybean with *Bradyrhizobium japonicum* inoculant with or without N and foliar fertilizer resulted in about 25% and above nodule dry weight increase as against the Control. Indicating that the introduced strains were compatible with the indigenous strains especially with the initial application of 25kg N ha^{-1} thereby aggravated substantial level of increase in nodule dry weight. As affirmed by Fatima *et al* (2007) who reported that nodule formation and its nitrogen fixation activity by *B. japonicum* is dependent on the presence of a compatible strain in a soil for a particular soybean variety. Moreso that the sole use of inoculation and control plot reviled that soybean growth cannot 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 and therefore can be induced that the combination of 25kg Nha^{-1}+INO 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 constituents of nucleotides, proteins, chlorophyll and enzymes, is involved in various metabolic processes and has direct impact on vegetative and reproductive phases of plants. Again the sole use of *Bradyrhiobium japonicum* inoculant, sole foliar fertilizer (BX) and control recorded the lowest biomass dry weight meaning that inoculation alone is not able to sustain soybean development and the soybean plant also required some nutrients at the early growth stage before foliar fertilizer application was done.

Pod formation could be explained with regards to all the used fertilizer sources, because the parameter was taken after the split application of N and foliar fertilizer. The statistical mean value shows that the use of sole 25kg Nha^{-1}, BX and their combinations was 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. Similar Lambon (2016) reported that the higher levels of N fertilizer levels (45kg N) produced ha^{-1} significantly higher pod numbers than the 15 and the 0kg 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). It was also observed that sole application of 25kg Nha^{-1}, BX, INO, 25kg Nha^{-1}+ BX and INO+BX had pod number and pod weight significantly ($P<0.05$) at par with the combinations of 25kg Nha^{-1}+INO+BX, 50kg Nha^{-1}+INO+BX and 75kg Nha^{-1}+INO+BX, while the Control recorded the least in all. 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). It has also been pointed out that leaves and stems are the major contributors to N supply to the seeds, while N from the pods constitute a temporary reserve for seed filling (Pate, 1985; Peoples and Dalling, 1988). They indicated that, pods are closer to the developing seed and are first to supply the seed with N but this supply ceases shortly in a couple of weeks. However, the response of crop to foliar fertilizer application rapidly reflects in 3 - 4 days while nutrients applied to the soil takes five to six days (Fageria *et al*., 2009). The authors further 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. It also confirms an earlier report by Fageria *et al*. (1997) that legume grains yield is a function of number of pods per plant. Sole BX recorded 19%, 50% and 60% over sole 25kg Nha^{-1}, INO and Control. Which is an indication that the use of foliar fertilizer just as been reported by some researchers has 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 macro nutrients which 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. This rate of ion passage through the cuticle and the epidermal tissues of the leaves depend on many factors such as the concentration, physical and chemical properties of the sprayed ion and micronutrients which are needed in limited quantities (Fageria *et al*., 2009). 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 effect of nutrient Deficiencies on BNF (Zahran, 1999). Oko *et al*. (2003) reported that foliar application of urea increased soybean grain yield; between 6 and 68% higher than the Control. Moreover, the effect of foliar fertilization on grain yield according to Mallarino *et al* (2001) depends upon the application period of the different growth stages of soybean. It is also most successful for supplying micronutrients, and more effective and economical because some of the nutrients, such as iron, are easily immobilized in the soil (Fageria *et al.*, 2009). The highest grain yield was recorded by soybean on 50Kg Nha^{-1}+BX plot with 45%, 31%, 22%, 21% and 44% over 25kg Nha^{-1}+BX, INO+BX, INO+25kg Nha^{-1}, BX and 25kg Nha^{-1} respectively with 93% significance over the Control, it was also realized by Lambon (2016) that in 2012 at Nyankpala, the 45kg N yielded the highest ha^{-1} grain of 2146 kg, however the application of

50kg N ha^{-1}+BX and INO+50 (3587 and 3172 kg ha^{-1}) in the same study area gave 1000 and above grain yield advantage over Lambon's report. Meaning that indeed the additional fertilizer supplement added at mid-vegetative till early podding stage of soybean development serve as a nutrient source which sustain soybean through reproductive stage when the nodules are assumed to have ruptured for efficient pod formation and seed filling (Nutrient sink). According to Chaturvedi (2005) nitrogen nutrition influences the content of photosynthetic pigments, the synthesis of the enzymes taking part in the carbon reduction and the formation of the membrane system of chloroplast. The sole and combinations of all the treatments (BX, INO, and N-level) performed better than the Control, except sole INO which had just 7% increase over the Control, infact the least produced treatment (INO+75kg Nha^{-1}) recorded close to 30% increase over the Control. Lending credence to the fact that indeed there is need for the application of fertilizer (BX, INO, N-Levels) and especially the top dressing of N to give 50kg N ha^{-1} and the application of foliar fertilizer at mid-vegetative stage till early podding stage for soybean sustenance till maturity, however the choice of fertilizer to adopt is left to the farmer with regards to the availability of the resources and his financial capability.

Conclusion and Recommendation:

The use of various sources of fertilizer, indeed contributed positively to the performance of soybean in the study area, meaning that the soil actually required some level of fertilizer supplement to enhance soybean cultivation. 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 ability to purchase the required fertilizer. It was glaring that soybean indeed requires complementary application of fertilizer at the mid vegetative – early pod filling stage, however the highest produced treatment (50kg Nha^{-1}+BX) performed significantly at par with some of the other treated plots such as the other levels of N+BX, the N-levels+INO, the N-levels+INO+BX and even some sole application of fertilizer. Hence, the highest grain yielded plot (50kg Nha^{-1}+BX) recorded 20% and above grain yield increase compared to sole BX, INO+25kg Nha^{-1}, INO+BX and INO+25kg Nha^{-1}+BX but with close to 100% grain yield increase over the control. While the use of sole BX, INO+25kg Nha^{-1}, INO+BX and INO+25kg Nha^{-1}+BX recorded at least 60, 59, 47 and 50% grain yield increase over the control respectively, hence can also be adopted depending on the farmers choice.

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