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THE EFFECTS OF COMBINED APPLICATION OF ASH+NODUMAX AND FERTIPLUS 3-2-7 FERTILIZERS ON PHYSIOLOGICAL GROWTH AND YIELD OF SOYBEANS IN LAFIA

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ABSTRACT
An experiment was carried out at College of Agriculture, Science and Technology, Lafia, Research and Teaching farm in 2019 to 'investigate the effects of combined treatment of ash+nodumax and Fertiplus 3-2-7 fertilizer on physiological growth and yield of Soybean. Routine analysis was carried out on the field in both cropping seasons using standard analytical procedures. The field was manually cleared and demarcated into plots measuring 2.5m x 2.5 m. Four ridges of 2.5 m long and a spacing of 0.75 m were constructed per plot with a 1m inter plot boundary. Three fertilizer sources; Nodumax+ash (combined), and Fertiplus 3-2-7 that served as treatments, were properly applied based on specifications. There were plots without fertilizer application that served as control. Treatments were replicated two times and laid out in a Randomized Complete Block Design. Soybean seeds of the variety TGX-1935-3f, TGX-1951-3f, and TGX-1904-6f were drilled into the ridges. The crop was grown to maturity within the season and harvested after twelve weeks. Data collected was subjected to the analysis of variance (ANOVA) using gens tat 12.1 edition. Significant difference among means was observed, and Fischer's least significant difference was used to separate means. Results from this study showed that there was response to treatment application during the period of plant growth.The result showed that the highest records of all parameters were observed in combined treatment of nodumax+ash, which gave the best yield in terms of grain weight, while Fertiplus 3-2-7 treatment gave the best result in terms of vegetative growth.The result was thus concluded in this order: Combined ash+nodumax treatment >;fertiplus 3-2-7 treatment.
Keywords: Fertiplus 3-2-7, Ash, Nodumax,

INTRODUCTION
The soybean (Glycine max (L).Merr,are species of legume native to Southeast Asia(Shurtleff et al;2009) It is an important legume crop in terms of total world production. The United States, Brazil, and

Argentina were the leading producers of soybean in 2005.These countries represent 80% of global soybean producers.(Shurtleff, et al;2009; USDA, 2018). However by 2018, three countries; Brazil, Argentina, and the United states are projected to produce over 82% of the world soybeans, while the top importers were China 41%,European union 22%,Japan 6%,and Mexico 6%.(*Patal*,2008).

Soybean is considered as highly nutritive food for humans and livestocks.(Berglund,2002.Akparobi,2009).Soybean contains about 20% oil on dry matter basis with 30%-50% protein (Kwarteng &Towler 1994).Soybean (Glycine max) has recently become a popular crop in Nigeria due to its high protein content(*Hymowitz, Newell*, 1981) Soybean is an excellent source of protein 35%-40%.The soybean seed is the richest in food value of all plant foods consumed in the world. Soybean is also rich in minerals and vitamins such as iron, zinc, copper, thiamin, riboflavin, niacin (Singh *et al.* 2006).Soybean is one of the most important oil crops in the world. It is the world's leading source of oil and protein. It has the highest protein content (40%) of all food crops and is second only to groundnut in terms of oil content (20%) among food legumes (Gurmu et al 2009).

Soybean is herbaceous erect, grown annual, warm climate plant.(Simmond et al.1999.The Soybean plant grows in distinct morphological stages developing from seeds into a fully mature plant. Soybean form inconspicuous fertile flowers borne in the axil of leaves and are white pink or purple. Depending on variety, node growth may cease once flowering begins. (Purcell et al.2014). Soybean is widely grown for its edible bean and is cultivated successfully in climate with hot weather with optimum growing condition. Temperature below 20^{0}C (68^{0}F) and over 40^{0}C (104^{0}F) result in stunted growth. (Heuze et al.2015.

The optimum growing conditions in mean temperature is between 20-30^{0}C,(68-86^{0}F).Temperature below 20^{0}C(68^{0}C), and over 40^{0}C (104^{0}C) Leads to stunted growth. Soybean requires about 15--32^{0}Cfor

germination, and higher temperature for rapid growth. (USDA, 2016.Fargione,et al.2008). Minimum soil temperature of 15.5^{0}Cis needed for rapid germination and growth, and minimum temperature of 10^{0}C for effective growth depending on day length. (Riaz et al (2006). Soybean can grow in wide range of soils, preferably in alluvial soils with a good organic matter content. Soybean alsopreferred a slight soil acidity of pH 6.5, with well drained loamy soil or sandy loam soil, and may alsothrive well in warm, fertile, well-drained, sandy loam soil.(Duzan,2004).The best soil type is sandy loam having good organic matter content.(*Akande etal.2007*).

Among the legumes the soybean plant is value for its high protein content (33%-45%).and oil content of approximately 20% and is considered as highly nutritive food for human and livestock's (Berglund,2002).Soybean products are used for human consumption and these includes soy ice cream, margarine, soy yoghurt and soy cheese(*Strom et al.* 2001)and industrial products such as oils, soap, cosmetics, resins, plastics, inks, solvents, and clothing.(*Lucas et al.* 1995).Soybean is processed into flour and its oil is used in local paint, cosmetics, and soap making industries(*Heuze et al.*2015).Soybean is consumed in Nigeria as soya milk. The cake is used for livestock feeding and the flour is added to pap as food for infant and children. About 97% of the soybean meal is used in livestock feeds.(*FAO..2015*). Soybeans are exceptional source of essential nutrients,36% dairy value,37% dietary fiber. Protein and soybean oil content amount contains 56% of dry soybeans by weight (36% protein, and 20% fat, 30% carbohydrates, 9% water, and 5% ash.(Strom et al.2001).Lubungu et al 2013, reported that fermented soy-food includes soy sauce, fermented bean paste, and textured vegetable proteins (TVP) are ingredient in many meat and dairy substitute. Among many uses, soy flour thickens sauces, prevents stalling in baked food and reduces oil absorption during frying. Baking food with soy flour gives it tenderness, moistness, a rich color, and a fine texture (Lim, 2012). This study will be carried out with the following objectives in mind:

1. Evaluate the effect of different fertilizer sources on physical and chemical properties of the soil
2. Evaluate theinteraction effect of nodumax (bio-fertilizer) and sources on thegrowth, nodulation, and yieldof soybean.
3. To compare the performances of the three soybean varieties in response to the application of the various treatments.

MATERIALS AND METHODS

The field experiment was carry during the rainy season of2019 cropping seasons at the Teaching and Research Farm College of Agriculture Lafia. Located in the Southern Guinea Savanna Zone, latitudes 8^0 29 30^0 N and Longitudes 8^0 31 0^0 E. The experimental field was manually cleared of grasses and other prevalent weeds, and ridges were constructed. Each plot measures 2.5m^2 and a spacing of 0.75m.Three seeds were planted per hole and plants were later thinned to two plants per hole at a spacing of 25cm apart. Weeding was done before plant reaches flowering growth stage. Small hoes, big hoes, and cutlasses were used in constructing the beds. The soybean seeds were soaked in water for 1min.and removed. About 50g of gum Arabic was completely dissolved in hot water, and allowed to cool down. Considerable quantity of nodumax was thoroughly inoculated with the soybean seeds, and left to air dried under the shade for about twenty (20) minutes before planting. It also serves to replace nitrogen fertilizer (*IITA, 2014*).

Fertiplus 3-2-7 (Liquid fertilizer) was applied as foliar spray four (4) weeks after planting when plant vegetation were fully established. One (1) ml of liquid fertilizer was applied to two (2) liters of water, thoroughly shaken and applied to the soybean plants. This was repeated at seven days' interval using hand sprayer. Ash was applied alongside soybean seeds treated with nodumax at 40kg/ha (1.2g) ash at 15 % P_2O_5 in ash analysis. About 7.5kg ash was applied for complete plot size. The experiment was laid out in split plot with Randomized Complete Block Design (RCBD), in two replications. Each replication consisted of nine ridges with sub plots per replication, The subplots were made up

of fertilizer sources. The fertilizer sources includes; ash+nodumax (bio-fertilizer), Fertiplus 3-2-7 ((Liquid fertilizer) and a control.

Soil Collection and Laboratory Analysis

Surface soil samples of 0—15cm depth from the site of the experiment were collected randomly at the Teaching and Research Farm of College of Agriculture, Science and Technology, lafia using the soil auger. The whole field was sampled randomly at the beginning and the composite samples were bulked and analyzed in the laboratory before planting, (based on the plots).soil sample were collected in each plot and analyzed in the laboratory. Air dried samples of the soil were sieved through 2 mm sieve and analysis of the physical and chemical properties were carried out. The following parameters were analyzed using standard laboratory procedures: Particle size was done using hydrometer method (*Bouyoucos*, 1951) as described by *Van reeuwijk*(1992),Soil pH was measured by glass-calomel combination electrode in a 1:2 soil/water ratio(*VanReeuwijk,(1992),*Organic matter content was determined using wet acid digestion (*Walkley and Black*, 1934) as modified by Nelson and summers, (1982),total nitrogen was determined using the macro-kjeldahl digestion and distillation procedures, available phosphorous was determined using the Bray-1 method (Bray and Kutz, 1945), exchangeable acidity (Al^{3+} and H^{+}) was determined using titration method (*Page et al.* 1982),exchangeable bases (Ca, Mg, Na and K) were determined by extracting with neutral normal ammonium acetate solution buffered at pH_7. Sodium and Potassium in the extract were determined using the flame photometer (*Black*, 1965), while Ca and Mg in the extract were determined using atomic absorption spectrophotometer (AAS),(Page *et al*, 1982).Calcium determination was done using 1.0ml lithium oxide solution added to the original solution to unmask Ca, from Mg. Sodium was analyzed by flame spectrophotometer.(Jenway model)
Soybeans varieties. The variety of soybeans, TGX-1935-3f, TGX-1951-3f,and TGX-1904-6f were sourced from University of Agriculture, Makurdi seed center in 2019.

Yield and Yield Components Data

The yield components were determined at harvest maturity. Number of primary branches/plant, number of pods/plant and plant height were determined from five randomly selected plants from two centre rows of each plot. Plant height was measured with the help of ruler. Number of primary branches and number of pods/plant, Number of pods were picked from the plants and then counted at flowering and harvesting stage. These were then determined using an electronic weighing balance.

Growth and Yield Parameters.

The following growth parameters were measured:*Days to first flowering after planting, *Days to 50% flowering, *Days to first podding,*Days to 50% podding *Plant height per plant in centimeter (cm) was taken at vegetative and flowering growth stage.*Average number of leaves at vegetative growth stage per plant, *Average number of nodules per plant at vegetative and flowering growth stage,five plants from each replicated plots were dug out to assess root systems for nodulation intensity, at the flowering stage of soybean development. Yield parameters were measured for the followings:*Root weight (grams) per plant at vegetative and flowering stage, *Dry root weight five (5) plants per plot after air drying (grams)*Nodules weight (5) plants per plot after air drying. *Weight of the whole plants per plot after harvest (grams), Seeds from plants for each plot harvested are extracted and weighed, at the end the yield were converted to kg/ha .About one hundred (100) seeds of the harvested soybean seeds from each plot were collected and weighed (grams) using electronic weighing balance

Statistical Analysis

Data generated from the experiment were subjected to analysis of variance (ANOVA).gen stat release 12.1(twelfth edition) was used for the analysis of the data. Significance of the treatment applications on the different soybean varieties under investigation were tested.

Information was grouped using Fischer's least significant differences (FLSD) and 95% confidence limits to separate means.

RESULTS

The physical and chemical properties of the soil in the experimental location in 2019.

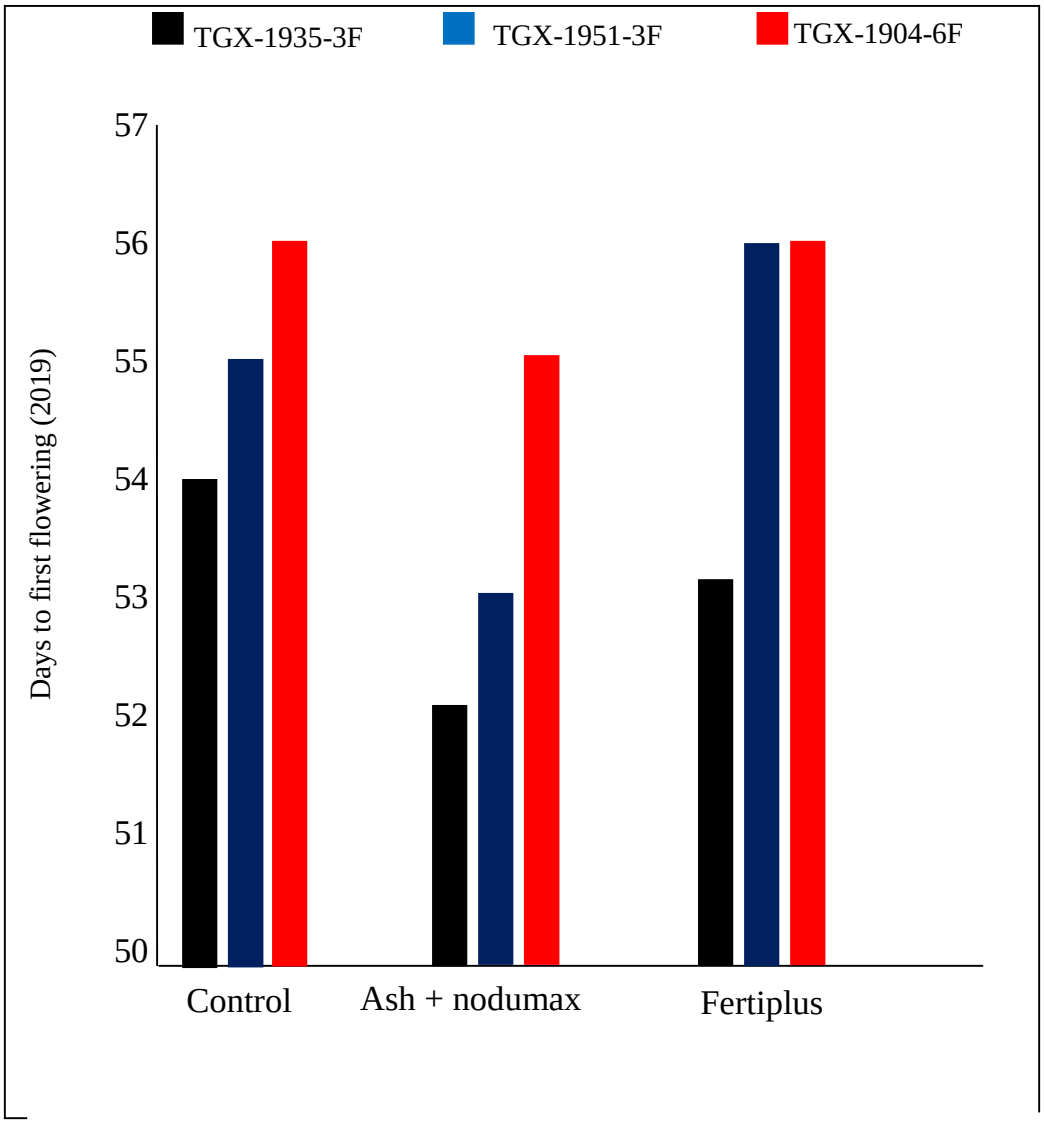
The physic-chemical properties of the soil in the experimental site (table 1) showed that the soil was loamy sand.The soil pH for the experimental location is 6.02; (moderately acid),. The organic carbon contents of the soil (1.66) is low.. The amount of organic matter in the soil is generally low, while the percentage nitrogen is also low, as rated by Metson 1961. The available P-(ppm) Bray 1 (2.39) cmol/kg is generally low, while the exchangeable cations among the exchangeable bases show slight variations. The K and Ca values; 0.30, 2.25 respectively, are generally low, The Mg value 1.50in is moderate. The Na content (0.20) is low. The C.E.C of the soil Cmol/kg (**4.87**) is very low while the percentage base saturation (94.0 %) is very high

Table.1 Physical and Chemical Properties of the Soil in the Experimental location in 2019

Properties	Sample Code (0-15cm) 2019
Sand	85.7
Silt	3.09
Clay (%)	10.4
Texture	LS
pH H_2O	6.02
Total N (%)	0.18
Organic carbon (%)	1.66
Bray-1 P(Mg L^{-1})	2.39
K (C mol Kg^{-1})	0.30
Na (C mol Kg^{-1})	0.20
Ca (C mol Kg^{-1})	2.25
Mg (C mol Kg^{-1})	1.50
Exchangeable acidity.	0.44
Effective CEC	**4.87**
TEB (C mol Kg^{-1})	4.39
B.S (%)	94.0

Fig.1: Days to first flowering

The result in fig.1 on days to first flowering in 2019 showed that soybean variety TGX-1935-3f, flowered at 52 days after planting when ash+nodumax was applied, while TGX-1904-6f flowered late at 56 days after planting in control and fertiplus treatments.

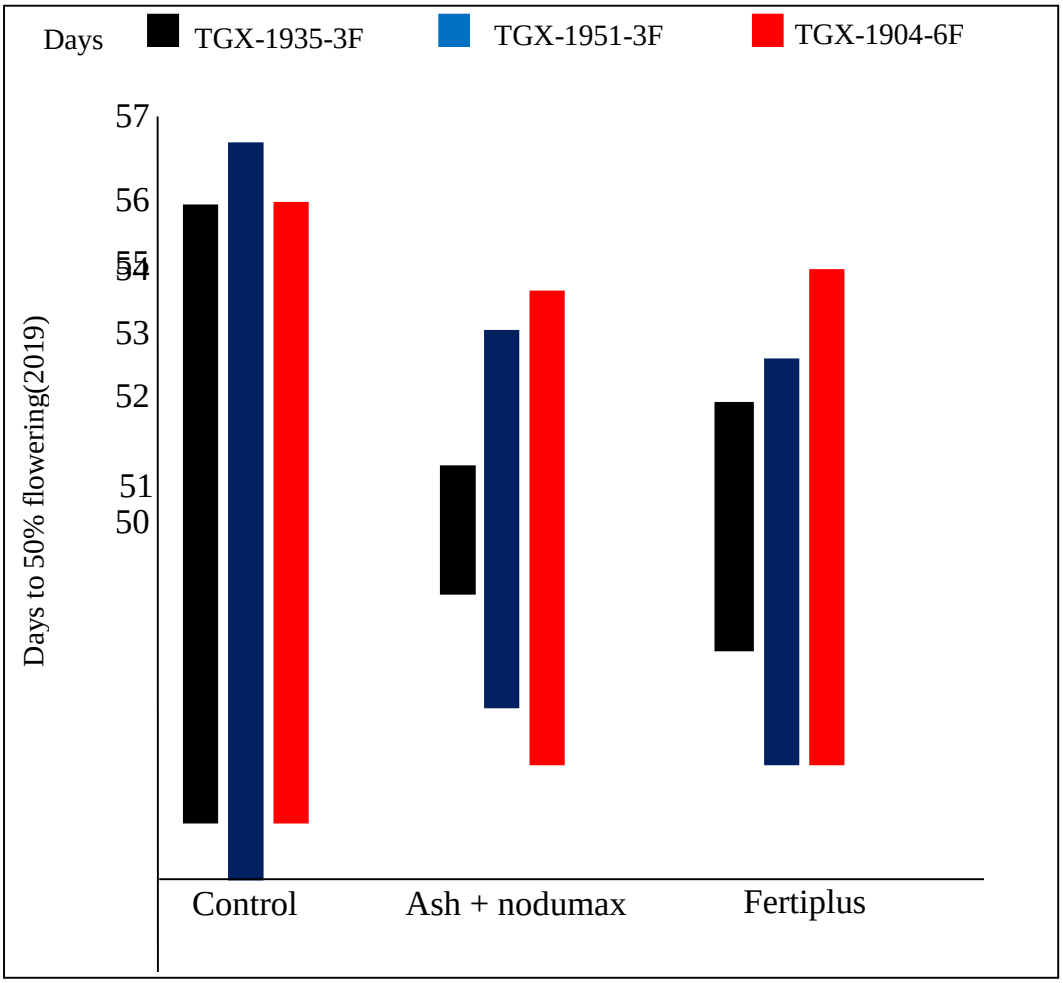


Days to first flowering

Fig 2 Days to 50% Flowering

The result in fig 2 on days to 50% flowering showed significant changes as there was early flowering in TGX-1935-3F.About 50% of the plants flowered at 51 days in ash+nodumax treatment. The longer number of days (56) to 50% flowering occurred in control treatment for TGX-1951-3f.

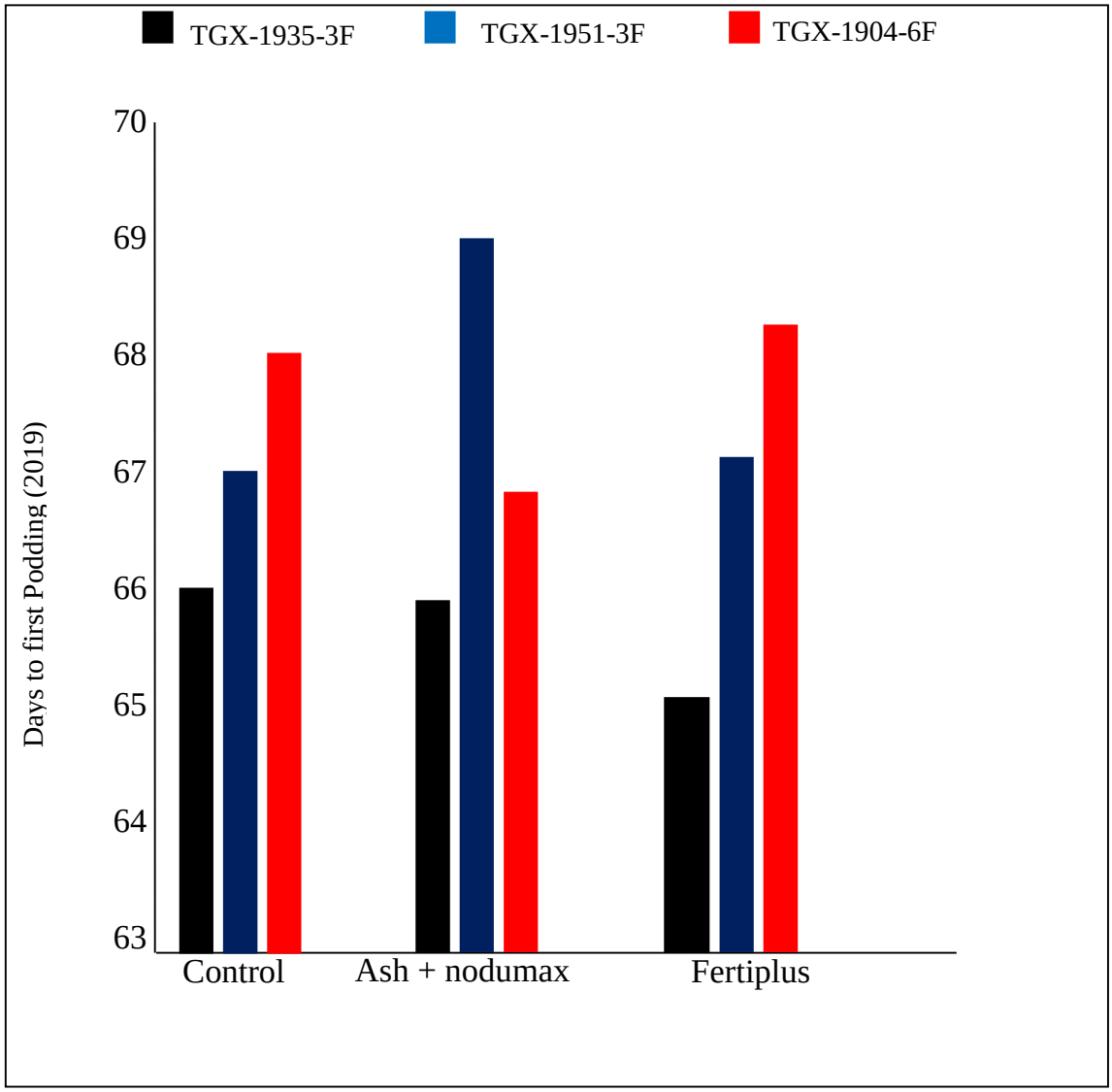
Fig 3: Days to First Podding



Days to 50% flowering

The Days to first podding (fig.3) showed that early podding occurred withfertiplus applicationin soybean variety TGX-1935-3F,65 days after planting, while soybean variety TGX-1951-3F, flowered late at 69 days after planting in ash combined with nodumax treatment.

Fig.4: Days to 50% Podding



The result on days to 50% podding (fig.4).The result also showed early podding at 50% for ash + nodumax treatment, 74 days after planting. The longer time taken to produce 50% podding occurred in control and ferti-plus treatments 78 days after planting in soybean variety TGX-1951-3F and TGX -1904-6F respectively.

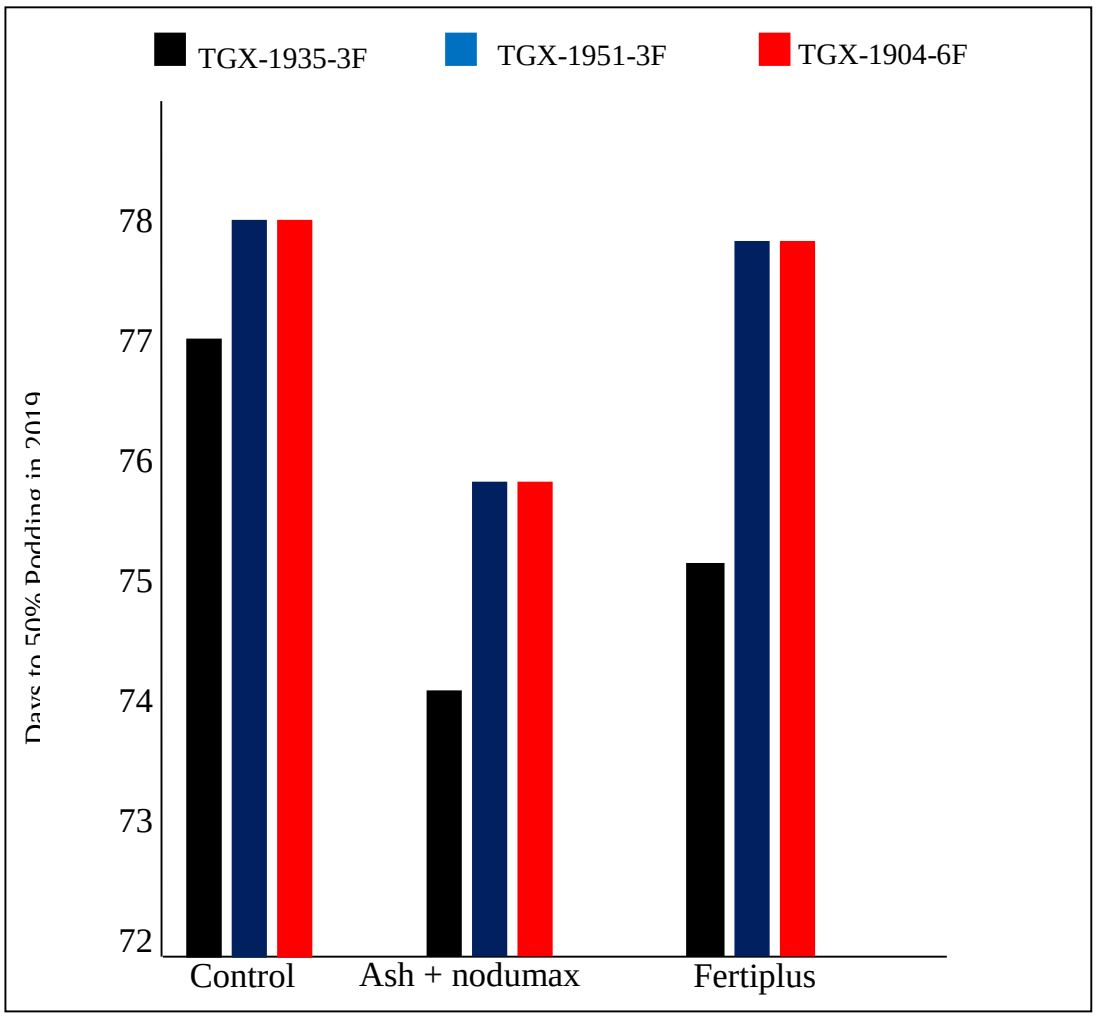


Table 2: Effects of fertilizer treatments on plant height.

The result on height of plant parts (table 2) showed that plant height was highest (72.06cm) on the average in ash+nodumax treatment at maturity growth stage. This trend continues both at the vegetative and flowering stages of growth when pods began to form. Ash + nodumax treatment increases the height of soybean plant significantly (62.99cm) and (56.16cm) respectively. Differences among the treatment means are not significant at p>0.05.

Table2 :Result on the effect of fertilizer treatment on plant height

	Plant Height (cm)		
Treatments	Flowering stage	Vegetative + podding	Plant at maturity
Control	47.68	55.77	63.75
Ash +nodumax	56.16	62.99	72.06
Fertiplus 3-2-7	41.29	54.99	58.75
LSD	11.93	10.37	8.56

Mean differences on the same column greater than the LSD are statistically significant p (0.05)

Table 3: Effects of fertilizer treatments on height of soybean varieties.

The result on the main effects of soybean varieties (table 3) revealed no significant differences statistically in height increased at various stages of growth (p 0.05),however little variations occured at maturity stage with significant increased (73.30cm) in TGX-1935-3f. However, the average means height (59.28cm) of TGX-1951-3f was higher than (58.87cm) for TGX-1935-3f and (54.19cm) for TGX-1904-6f at vegetative and podding stage respectively. Differences among treatment means at vegetative and flowering stages of growth are not significant statistically.

Table 3: Effect of fertilizer treatments on height of Soybean Varieties

	Plant Height (cm) at:		
Varieties	Flowering stage	vegetative+pod stage	Plant at maturity
TGX-1935-3f	53.86	58.87	73.30
TGX-1951-3f	48.15	59.28	63.58
TGX-1904-6f	45.80	54.19	61.12

LSD	9.24	8.03	6.63

Mean differences on the same column greater than the LSD are statistically significant p (0.05)

Table 4: Interaction effects of fertilizer treatments and varieties on height of plant parts

Interaction among treatments and varieties on plant height (table 4) was highest in TGX-1935-3f (62.10cm) at flowering stage, and (74.10cm) at vegetative stage in ash+nodumax treatment. The lowest interaction effect is in Fertiplus 3-2-7 fertilizer application with TGX-1904-6f (33.60cm). Interaction effect was highest at maturity stage in ash+ nodumax treatment (83.20cm). Interaction effect in TGX-1935-3f in ash+nodumax treatment significantly increased the height of soybean plant at maturity

Table 4 :Interaction effect of fertilizer treatment and varieties on heigh of soybean plant

Treatments	Variety	Plant Height (cm) at:		
		Flowering stage	Vegetative + podding	Maturity
Control	TGX-1935-3f	59.90	54.80	67.90
Control	TGX-1951-3f	57.70	54.10	67.30
Control	TGX-1904-6f	48.70	51.50	65.70
Ash +nodumax	TGX-1935-3f	43.40	74.10	83.20
Ash +nodumax	TGX-1951-3f	47.10	55.50	63.50
Ash +nodumax	TGX-1904-6f	52.60	57.80	59.80
FP 3-2.7	TGX-1935-3f	62.10	63.40	76.90
FP-3-2-7	TGX-1951-3f	44.00	59.00	67.30
FP-3-2-7	TGX-1904-6f	33.60	49.40	55.70
LSD(P<0.05		20.67	17.06	14.82

Means differences on the same column greater than the LSD are statistically significant p<0.05

Table 5. Effects of fertilizer treatments on soybean varieties.

The effects of fertilizer treatments on soybeans varieties (table 5) showed no significant differences statistically at p 0.05. The highest establishment counts occurred in TGX-1935-3f. Number of leaves per plant was however higher in TGX-1951-3f on the average.

Varieties	Est.count	Whole plant	Number,of leaves	Number,of pods per plant
TGX-1935-3f	108.74	51.93	46.10	68.00
TGX-1951-3f	63.70	48.18	49.08	56.33
TGX-1904-6f	85.15	45.75	42.10	62.63
LSD	15.90	8.55	9.93	24.92

The mean differences on the number of pods showed no significant differences at p 0.05, while TGX-1935-3f produced more number of pods on the average. Mean differences in the same column greater than the LSD are statistically significant at p.0.05

Table 6. Interaction effects of fertilizer treatments and varieties on soybean parts

Interactions effects between fertilizer treatments and varieties (table 6) showed no significant difference statistically. Interaction effect between Fertiplus 3-2-7 and TGX 1951-3f produced a higher number of establishment counts (118.10), followed by ash+nodumax with TGX-1935-3F (111.5).Interaction effect between Fertiplus-3-2-7 and TGX-1951-3f produces higher establishment counts on the whole plant (97.50). Average mean difference in interaction between treatments and varieties in terms of establishment counts are not significant statistically. Interaction effect between treatment and varieties produced higher number of nodules in ash+nodumax treatment with TGX-1935-3F (36.30). Number of leaves increases highly with Fertiplus 3-2-7 treatment application. This showed higher interaction effect with TGX-1935-3f (56.70), followed by ash+nodumax treatment (54.20) with TGX-1951-3f. Interaction between Fertiplus and TGX-1951-3F on number of pods was higher (66.50) while interaction between control and TGX-1904-6F produced the lowest interaction effect (36.00)

Table:6 Interaction effects of fertilizer treatments and varieties on plant parts.

		Number of plant parts of:				
Treatments	Varieties	Est. count	Whole plant	No of nod.	Number of leaves	Number of pods per Plant
Control	TGX-1935-3f	62.10	44.20	12.10	36.80	58.20

Control	TGX-1951-3f	55.60	57.70	29.70	48.50	49.20
Control	TGX-1904-6f	95.10	48.70	16.90	44.00	36.00
Ash +nod	TGX-1935-3f	111.5	43.40	36.30	54.20	54.80
Ash +nod	TGX-1951-3f	57.80	47.10	13.50	47.50	64.00
Ash +nod	TGX-1904-6f	92.10	52.60	20.30	51.40	62.30
FP 3-2-7	TGX-1935-3f	118.10	58.80	29.50	56.70	54.70
FP 3-2-7	TGX-1951-3f	68.20	97.50	15.10	36.60	66.50
FP 3-2-7	TGX-1904-6f	56.10	39.90	18.20	44.00	52.70
LSD		35.55	19.12	24.53	22.21	55.72

Mean differences in the same column greater than the LSD are statistically significant p<0.05

Table.7. Effects of fertilizer treatments on weight of soybean Parts

The result in table 7, revealed that nodumax+ ash, treatment significantly increased the weight of nodules at flowering stage (1.14g) .The low weight gain was observed in ferti-plus treatment (0.56g). The result also showed that ash +nodumax application increased weight gain of the whole soybean plant per plot (123.10g), while the low weight gain was observed in plot treated with fertiplus fertilizer (99.60g). The weight of one hundred (100) seeds per plot showed that fertilizer treatments leads to a significantly higher seeds weight after harvest (32.62g). Ash+nodumax treatment per plant at flowering and podding stage produced higher fresh root weight (6.04g). Higher dry root weight per plot was observed in ash+ nodumax treatment (66.90g).and at Fertiplus treatment per plant (2.68g) Dry root weight per plan/ plot after harvest were significant at p 0.05.

Table 7: Effect of fertilizer treatments on weight of soybean parts

Treatments	Weight of Plant parts (g)						
	Nodules,wt.at flowering	Fresh root wt. at flowering	Whole,plant wt. /plot	Whole Plant,wt./rep	100 seeds wt./plant,after harvest.	Dry roots wt./plant	Dry root wt./plot
Control	0.58	3.64	101.69	949.00	25.51	1.74	59.43
Ash +nodumax	1.14	6.04	123.10	980.00	32.62	2.36	66.90
Fertiplus 3-2-7	0.56	2.94	99.60	1060.00	26.02	2.68	54.38
LSD	0.48	1.82	41.42	504.10	16.29	0.77	11.20

Mean differences in the same column greater than the LSD are statistically significant

Table.8. Main effects of varieties on weight of soybean (parts)

The result in table 8 showed that nodules weight at flowering was higher in TGX-1935-3f, (0.98g), while the late variety, TGX-1904-6f, produced less nodules weight (0.71g). The production of nodules among the three soybeans varieties shows no significant differences statistically at p 0.05. The result on whole plant weight per plot was significantly higher in TGX-1951-3f (117.60g), while the least weight occurred in TGX-1935-3f. (103.78g), Variety TGX-1951-3f has higher weight than TGX-1935-3f and TGX-1904-6f respectively. Differences in weight gain of the three varieties are not significant statistically at p 0.05. The weight of 100 seeds per plot of the three varieties showed that TGX-1951-3f produced higher seeds weight (31.31g) per plot.The weight gain among the three varieties are not significant at p>0.05. The weight of dry roots per plant showed that TGX-1935-3f produces higher dry root weight per plant,(2.61g), while TGX-1904-6f produces lower dry root weight (1.88g) per plant.Mean weight of dry root showed no significant difference statistically at p>0.05. However, there is significant difference in the dry root weight gain between TGX-1951-3f (2.02g) and for TGX-1904-6f. (1.88g). TGX-1951-3f, showed higher dry root weight (64.68g) per plot than TGX-1935-3f. (59.84g) Dry root weight show a significant difference between TGX-1951-3F and TGX -1904-6f while there is an insignificant differences weight gain of TGX-1935-3F and TGX-1904-6f

Table 8 : Effect of varieties on weight of soybean (parts)

Varieties	Weight of Plant parts (g)						
	Nodules wt.at flowering	Fresh root wt.at flowering	Whole plant wt./plot	Whole plant wt./rep	100 seeds Wt. /plant	Dry roots wt./plant	Dry root wt./plot
TGX-1935-3f	0.98	5.04	103.78	1097.00	26.28	2.61	59.84
TGX-1951-3f	0.79	5.44	117.60	1131.00	31.31	2.02	64.68
TGX-1904-6f	0.71	3.92	110.40	975.00	30.37	1.88	52.48
LSD	0.37	1.41	31.94	390.50	12.62	0.60	8.67

Mean differences in the same column greater than the LSD are statistically significant p.0.05

Table.9. Interaction effects of fertilizer treatments and varieties on weight of soybean parts

The interaction effect between the varieties and treatment means are significant statistically at p>0.05. Interaction effect on nodules weight at flowering stage of growth was higher in TGX-1935-3f (1.89g) in ash + nodumax. Interaction effect was lower in TGX-1904-6f.(0.43g) in ash+ nodumax treatment. Root weight at flowering stage was higher in TGX-1951-3f (8.07g) in Fertiplus 3-2-7.while, TGX 1904-6f has lower interaction effect.(2.9g) Significant difference in interaction exists only between TGX-1935-3f in Fertiplus 3-2-7 and, TGX-1951-3f in ash+nodumax treatment. Interaction effect between varieties and treatment are not significant at p>0.05.

The lowest performance in whole weight gain per plant (685.0g) was found in TGX-1904-6f (control).while Interaction effect between varieties and treatments are not significant. Interaction effects on 100 seeds weight per plot is significant statistically at p 0.05.The 100 seed weight gain occured in TGX 1935-3f,in ash + nodumax (46.20g) followed by TGX-1951-3f (40.40g) in control Interaction effects of dry root weight per plant is significant statistically at p>0.05.Higher interaction effect on dry root weight per plant (2.65g) occurred in TGX 1935-3f (ash+nodumax treatment), while higher interaction effect on dry weight per plot (66.90g) occurred in TGX-1951-3F in ash+nodumax treatment, and is highly significant. The lowest interaction effect occurred in TGX-1904-6f.(41.40g) in Fertiplus 3-2-7

Table 9: Interaction effect of fertilizer treatments and variety on weight of soybean parts

		Weight of plant parts (g)						
Treatments	Variety	Nodulesat floflowering	Root At floflowering	Whole wt Plant/plot	Whole plant/plot	100 seeds/p	Dry roots/plant	D Dry/y root/plot
Control	TGX-1935-3f	0.45	7.28	82.00	1027.00	23.20	1.87	72.60

Control	TGX-1951-3f	1.20	6.45	181.80	1227.00	40.40	2.59	64.30
Control	TGX-1904-6f	1.05	4.39	105.50	685.00	34.20	1.74	55.10
Ash +nodumax	TGX-1935-3f	1.89	3.26	92.90	769.00	46.20	2.65	59.60
Ash +nodumax	TGX-1951-3f	0.86	4.70	105.70	1179.00	33.00	2.19	66.90
Ash +nodumax	TGX-1904-6f	0.43	2.97	106.50	899.00	25.00	1.29	51.70
FP 3-2-7	TGX-1935-3f	1.16	7.63	124.50	1065.00	34.20	2.53	64.80
FP 3-2-7	TGX-1951-3f	0.62	8.07	114.80	1328.00	30.80	1.99	68.40
FP 3-2-7	TGX-1904-6f	0.68	4.07	84.70	974.00	19.30	1.67	41.40
LSD (P≤0.05)		0.84	3.15	71.42	873.10	20.82	1.34	19.40

Mean differences on the same column greater than the LSD are statistically significant p>0.05

Table.10. Effects of fertilizer treatments on soybean biomass.

The result revealed that the highest biomass weight at flowering stage was observed in ash+nodumax treatment (55.61g), while the low biomass weight was observed in control treatment (32.60g). The weight of the air-dried whole soybean plant per plot increases significantly after fertiplus application (17.96g).This was followed by ash+ nodumax (13.49g). Air dried nodules weight for soybean plants responded highly to the application of nodumax+ash,(0.29g) The results showed no significant difference among the treatment means statistically at p>0.05

Table 10: Effect of fertilizer treatments on soybean biomass.

Treatments	Biomass of plant parts at: Flowering Stage	Air-dried wt./plot after harvest	whole	Air-dried nodule Wt.
Control	32.60	11.78		0.19
Ash +nodumax	55.61	13.49		0.29
FP- 3-2-7	38.77	17.96		0.23
LSD	23.38	4.11		0.15

Mean differences on the same column greater than the LSD are statistically significant (p0.05

Table 11. Effects of varieties on biomass of plant parts

The result on the effects of varieties on biomass of plant parts showed that TGX-1951-3f produced higher biomass (51.02g) while TGX-1904-6f produced an average lower biomass (39.42g). The air dried whole weight of the biomass was higher in TGX-1935-3f (14.62g) with no significant differences among the varieties. Air-dried nodule weight was higher in TGX-1935- with significant differences in the nodules weight of the three varieties at p>0.05.

Table 11: Effect of varieties on Biomass of plant parts

Varieties	Biomass of plant parts (g) at Flowering Stage	Air-dried whole wt./plot(after harvest)	Air-dried ıle Wt.
TGX-1935-3f	45.59	14.62	0.30
TGX-1951-3f	51.02	14.08	0.10
TGX-1904-6f	39.42	12.57	0.16
LSD	18.11	3.18	0.11

Mean differences on the same column greater than the LSD are statistically significant (p 0.05)

Table.12. Interaction effects of treatments and varieties on biomass of plant parts

The highest interaction effect on biomass weight (42.30g) occurred in TGX-1935-3f in fertiplus 3-2-7.The lowest interaction effect on biomass weight occured in TGX-1935-3f (23.62g) in ash+nodumx treatment (table 12). Interaction effect in TGX-1951-3F in ash+nodumax treatment resulted in higher biomass weight(17.73g) for air dried whole soybean biomass per plot after harvest.The lower interaction effect was found in TGX-1904-6f(7.79g).Interaction among the different treatments combination in terms of biomass weight is not significant statistically at p>0.05.Interaction between the varieties and various treatment combinations in air-dried nodule weight is significant statistically at p>0.05.

Table 12: Interaction effects of treatments and varieties on biomass of soybean Parts

		Biomass of plant parts		
Treatments	Variety	Flowering Stage	Air-dried whole wt./plot after harvest	Air-dried nodule Wt.
Control	TGX-1935-3f	42.12	13.25	0.23
Control	TGX-1951-3f	35.62	17.10	0.11
Control	TGX-1904-6f	39.85	10.11	0.13
Ash +nodumax	TGX-1935-3f	23.62	9.84	0.21
Ash +nodumax	TGX-1951-3f	29.21	17.73	0.36
Ash +nodumax	TGX-1904-6f	35.12	7.79	0.22
FP 3-2-7	TGX-1935-3f	42.30	11.93	0.32
FP 3-2-7	TGX-1951-3f	36.56	13.41	0.12
FP 3-2-7	TGX-1904-6f	25.39	10.48	0.20
LSD		40.50	7.12	0.26

Mean Differences onthe same column greater than the LSD are statistically significant (p <0.05

DISCUSSION

The soil pH of the experimental location (table1) was 6.09, indicating that the soil is medium to slightly acidic **(USDA, SCS, 1974, Adepetu, et al 2014).** This result is in harmony with the findings of **Shubhrata,**

2012, Adepetu *et al*.2014) that most soybean plants will perform well at a soil pH range of 5.5--7.0,in most calcareous soil. Shubhrata, 2012, further reported that "crops such as beans, Brussels, sprouts, carrots, peanut, soybeans, and most bulbs, can do well in moderately acid soils of pH 5.5 - 6.0. Stanton, 2012, asserted that when soil pH level exceeds 6.5 manganese deficiency symptoms can occur in lakebed and outwash soils. The optimum range of soil pH for most plants is between 5.5--7.5 Many plants can thrive outside this range.while others grow slightly under acid condition, while Harlin et al.(2005) stated that soil acidity can limit the survival and the growth of rhizobia in the soil and can also affect nodulation process and nitrogen fixation. Hungria and Vagas, 2000, reported that soil pH at values less than 5.5-6.0 can drastically affect rhizobia infection, root growth, and legume productivity. The pH range between 6.0 -7.0 is considered to be suitable for rhizobial growth.This pH range maximizes nutrient availability and biological nitrogen fixation in soybean plant.

The Soil Texture was Loamy sand. The national soybean research laboratory recommends loamy soil that is well drained for soybean cultivation because of its sand contents, and its ability to retain appropriate amount of water due to high silt and clay. The organic matter values of the soil are low in the range of 2-4%, while the organic carbon contents of the soil were observed to be medium.(Chude,et al;2012). Most of the values were between 1-2 % as reported by by Metson, 1961.The contents of O.C in this soil indicates that the soil contains good amount of organic matter,suitable for soybeans cultivation. The total nitrogen values are generally low.These values ranges between 0.1--0.2 in many of the plots, but in some instances, were observed to be higher in nodumax treatment. The higher values of N in plots treated with nodumax may probably be due to higher nodulation, which in turns means that more N_2 are fixed by rhizobial bacteria in the root zone. The available p (ppm) bray-1 was low .The value of P bray-1 in the study site in Lafia falls below 8. This is similar to the values reported by Enwenzor, et al; 1989. The decrease in soil P may have been influenced by the uptake of P by the plant roots from

the soil solution during the growing season. The low P levels of soil for the experimental area of this study might have been the reason for limited nodulation. These results suggest the need to apply P, either through application of inorganic P fertilizer or manure during cultivation of soybean on low P soils. The soil was low in Ca,Na,and K,(Chude,et al;2012),but moderate in Mg.both of which values were below the critical levels,(Aune and Lai,1995).Klinkinberg,and Higgins,1968,characterized the savanna as highly leached Ferruginous ultisols low in organic matter,nitrogen and P,but high in K content derived from base complex. The result demonstrates significant increased on some soil parameters, probably due to increased addition of organic matter contents, application of ash in combination with nodumax, and nitrogen fixation by soil rhizobium bacteria responsible for increased nodulation.. The result on days to first flowering, 50% flowering, first podding, and 50% podding (fig.1-4) respectively all showed a significant increased on the various growth parameters. First flowering occured at shorter days, 51 days after planting in ash+nodumax treatment. The result also showed that 50% of the flowers produced were observed in variety TGX-1935-3f in a treatment combination of ash + nodumax, 59 days after planting,meaning that the combined treatment can enhanced the early growth and yield of TGX-1935-3f.Furthermore TGX-1951-3f and TGX-1904-6f took longer days (64 days) to produce flowers in control treatment. Soybean varieties significantly differ in days to 50% flowering ($P \leq 0.05$). The number of days to 50% flowering ranged from 59 to 64 days. Days to first podding revealed that early podding was also observed in ash combined with nodumax treatment in TGX-1935-3f and TGX-1951-3f at 65 days after planting, while fertiplus 3-2-7 treatment produced late podding at 69 days after planting.

Days to 50% podding showed that ash combined with nodumax treatment also produced early podding 74 days after planting, while Fertiplus treatments produced late podding at 78 days after planting.
The variations in results on first flowering, 50% flowering, first podding, 50% poddings, apart from the significant effect of

ash+nodumax treatment, could be due to changes in soil, environmental and climatic factors during the cropping period.
The result on the effect of treatments on plant height (table2) showed a clear effect of different fertilizer treatments. A significant increased in plant height also occurred in treatment combination of ash+nodumax at flowering stage of growth. TGX-1935-3f increases significantly in height than the other varieties when ash combined with nodumax was applied.**Bonfim-silva,et al;2015**,reported that the nutrient contained in wood ash applied improved the soil fertility and enabled the development of more robust plants having greater height and stem diameter.Fertilization with wood ash also promote taller plant and thicker stem. Mean differences are not significant statistically at $p<0.05$, A clear effect of varieties on plant height, (table 3) showed no significant differences statistically among varieties. The average mean height of TGX-1935-3f was better than the rest. Thus, variety TGX-1935-3 responded significantly better in height increases than the other varieties. The result on the interaction effect of treatments on plant height (table 4), revealed that interaction effect between control treatments with TGX-1935-3f increases plant height significantly. While interaction effects between fertilizer treatments and varieties at flowering stage showed significant difference in plant height statistically. Interaction effect between fertilizer treatments and varieties at maturity showed no significant difference statistically at $p>0.05$. Interaction effect between ash and nodumax treatment with TGX-1935-3f also significantly increased the height of soybean plant.**Bezerra,et al**; **2016** reported that 'fertilization using wood ash enhance the plant nutrient uptake and promote taller plant'. The interactions among the three varieties of soybeans are significant statistically at maturity. The height of plants significantly increased in plots treated with ash + nodumax, this is quite visible in early variety, TGX-1935-3f. **Campbell,1990**, reported that ash is composed of many major and minor elements, and is also a good source of potassium, phosphorous and magnesium.This agrees with the report by **Hanway,and Weber, (1971)** that the increase in the growth of plant height on the average may be due to environmental and climatic

factors, which played significant role in increasing the height of the three varieties of soybean plant. The result on the effect of different treatments on number of plant parts (table 5). Revealed that Ferti-plu 3-2-7 application resulted in significant increases in establishment counts Whole plant per plot also showed no significant differences statistically among treatment means. Number of leaves per plant also showed no significant differences statistically. The combined treatment of ash with nodumax leads to a significant increase in number of leaves. Ferti-plus 3-2-7 treatment produced low number of leaves. Pods yield per plant were not significant statistically at p>0.05.it was also however observed that the treatment of the soybeans with ferti-plus 3-2-7 has greatly enhanced the production of pods in soybeans.The result on the effect of varieties on number of plant parts (table 6), showed that TGX-1935-35 produced higher establishment count while TGX-1951-3f produced significantly higher number of leaves .It could also be seen from the resultthat TGX-1951-3f produced higher number of pods per plant on the average. Mean differences between the treatments are not significant statistically, except in establishment count. **Lubungu et al. 2013,** reported that soybean offers a variety of potential benefits including diets and income for smallholder farmers and to production systems. TGX-1935-3F could be a good variety for commercial farmers especially when the issue of biodiesel production considered. It would result in more yields, more oil, and then more biodiesel. More oil would also mean the risks of stomach diseases and diabetes are reduced using soybean oil as reported by **Singh, (2006)** The interaction effect of treatments and variety presented in (table 7) on number plant parts indicates that interaction effect between fertiplus treatment with TGX-1935-3f produced more establishment counts, while Interaction between control treatment with TGX-1951-3f produced low establishment counts on the average. Significant increases in nodule production occured in TGX-1935-3f, while the mean differences in interaction between variety and different treatments are not significant statistically at p>0.05 for nodules numbers. Similarly, ash+nodumax treatment has significantly increased number of leaves per plant. The low leaves numbers was observed in control treatment with TGX-

1904-6f. The inoculation of seeds with rhizobium, increases nodulation, nitrogen uptake, seeds and protein contents of soybean.(*Wormer et al.* 1997, *Tahir et al.* 2009, *Beanie, et al.*2011).Soybean can obtain up to 50-75% of its N requirement from the air when nitrogen fixing bacteria have established functioning nodules on the roots.

The application of ash+nodumax has recorded a significant pods production per plant in TGX-1935-3f. Mean differences on the effect of treatments and varieties on number of plant parts in terms of nodules numbers, leaves numbers ,and number of pods revealed no significant differences statistically at p<0.05.The result on the effect of fertilizer treatments on weight of plant parts (table 8) showed that fresh weight of root per plant at flowering growth stage was higher on the average in plots treated with ash+nodumax.Review by **Mabrouk and Belhadj (2012)** stated that rhizobium legumes symbiosis strongly depends on the physiological state of the host plant. The treatment combination of nodumax with ash has significantly increased nodules weight at flowering stage. Low nodules weight was observed in fertiplus treatment.The result further showed an increased in dry root weight per plant in ash combined with nodumax treatment.**Bezerra,et al;2016**,further stated that 'the increase in the development of the root system of soybean plant facilitates greater soil volume to be explored thus encouraging higher water and nutrient absorption resulting in better plant development. Mean difference is significant between fertiplus treatment and control treatment, and not significant between fertiplus treatment with ash combined with nodumax and with single super phosphate combined with nodumax. The result of 100 seeds weight per plot showed that plots treated with ash and nodumax produces significantly higher seeds weight, while control treatment gave lower weight per plot. This result was in conformity with the finding of **Oad, et al** ;2002,as reported by **Herridge *et al.* (1984)** "that increasing or adding more inoculants into the seedbed led to more extensive distribution numerically and in depth, of rhizosphere,

improved nodulation and nitrogen fixation, and larger residual populations in the soil after harvest".

Dry root weight per plot showed an increasingly higher weight in ash+nodumax treatment with the low being in fertiplus treatment. Mean difference is significant between ash nodumax treatments. Whole plant weight per plot showed significant increase in ash+nodumax treatment with low in fertiplus treatment. Result on the effect of varieties on weight of plant parts (table 9) revealed that higher dry root weight per plot occurred in TGX-1935-3f. Dry root weight per plot showed no significant difference between TGX-1935-3f and TGX-1904-6f. A significant increase in nodules weight was found in TGX-1935-3f, while mean differences in nodules weight is not significant statistically. Fresh root weight at flowering stage is not significant .Variation in weight gain occurred between TGX-1935-3f and TGX-1904-6f.Mean differences in fresh root weight gain is not significant statistically at $p<0.05$.Weight of 100 seeds per plot showed TGX-1951-3F, increases significantly in weight gain in 100 seeds per plot. Dry root weight per plant revealed that TGX-1935-3f showed higher weight, with the low found in TGX-1904-6f. Mean differences between TGX-1935-3f and TGX-1951-3f, is not significant, while mean differences between TGX-1935-3f and TGX-1904-6f is significant. Result on the interaction effect of fertilizers and varieties on weight of plant (table 10) showed that higher interaction effect between combined application of ash and nodumax has increased nodules weightin TGX-1935-3f.Mean differences are significant between ash combined with nodumax and nodumax in TGX-1951-3f.Higher interaction between ferti-plus 3-2-7 application and TGX-1951-3f, Low interaction effect occurred between nodumax and TGX-1935-3f. Interaction effect between the three varieties and treatments per replication is not significant, while interaction effect between combined applications of single super phosphate fertilizer with nodumax is higher in TGX-1935-3f. Whole plant per plot showed that interaction between control treatments with TGX-1951-3f produce a

significant weight gain .Mean differences in whole weight gain per plot is significant.

A higher seed weight (100) per plot at flowering stage was observed to be in ash+ nodumax application with TGX-1935-3f.Interaction effect between treatments and varieties on 100 seeds weight per plot is significant statistically. Interaction effect between varieties and treatments on dry root weight per plan is significant. An increased in dry root weight was observed in nodumax treatment in with TGX - 1935-3f.Interaction effect between treatments and varieties increase dry root weight significantly in single super phosphate combined with nodumax treatment with TGX-1951-3f, while the low interaction is found in single super phosphate combined with nodumax application with TGX-1935-3f. Result on the effect of treatments on biomass of plant parts (table 11) showed a significant increase on biomass weight at flowering stage in ash +nodumax application.**Xavier, et al; 2003,** reported that optimum growth of soybean plant usually dependent on symbiotic relationships with mycorrhizal fungi and N fixing bacteria.Soybean like other nodulated legumes, utilizes two source of N for its growth, mineral N, in the soil and atmospheric N fixed in nodules.**(Keyser, and Fudi,1992)**.The N requirement of soybean can be met by both mineral N and symbiotic fixation.

A significant gain on air-dried soybean biomass occurred in Ferti-plus treatment, higher weight increases occurred on air-dried nodule per plant treated with ferti-plus 3-2-7 fertilizer. Mean differences is not significant. Result on the effect of varieties on biomass of plant parts (table 12) revealed that TGX-1951-3f gave a higher biomass. The effect of varieties on biomass of plant parts at flowering stage is significant statistically at $p<0.05$.The biomass of whole plant per plot showed a significant increased in biomass weight.Mean differences is significant statistically, TGX-1935-3f gave a higher air-dried nodules weight. The result on the interaction effect of treatments and varieties on biomass of plant parts (table 13) showed that interaction effect between ash + nodumax treatment occured in TGX-1935-3f.Interaction effect on air

dried biomass per plot showed that nodumax+ash application has significantly increase biomass of soybean TGX-1935-3f,The increased gain in biomass weight,and air dried biomass per plant might be as a result of an important function of ash in reducing soil acidity.**Darolt,et al;1993**,reported that 'ash is useful in lowering the soil acidity by promoting the neutraliuzation of hydrogen and toxic Aluminium via the release of the soiul carbonate content,and contains Ca,Mg,and micronutrients. Mean differences between treatments and varieties on air dried whole soybean plants are significant statistically. Interaction effect of treatments and varieties on air dried nodules weight increases significantly in TGX-1935-3f in ash +nodumax application. **Rashid, et al; 1999** reported an increase N uptake by plant to inoculation application.**Tamiru et al** also reported significant effect of rhizobial strains on nodule dry matter. Interaction effect of treatments and varieties was low in control treatment with TGX-1951-3f. Mean differences on the interaction effect between treatments and varieties is not significant statistically at $p<0.05$.

Thus the application of ash and the treatment of soybeans seeds with nodumax have a significant interaction effect in increasing the growth, nodulation and yield of different varieties of soybean plants as reported by **Bonfim-silva, *et al;*(2017)** that, "few legumes such as beans(Phaseoulus vulgaris L.) and soybeans (Glycine max (L.) Merr.Showed a biomass increase after wood ash application. Furthermore "the act of inoculation leading to nodulation was a means of conserving soil nitrogen which enhances the growth and yield of the crop". **(Oad, et al;2002).**

CONCLUSION

Results from this study showed the significance of nodumax a bio-fertilizer, ash, single Superphosphate fertilizer, and liquid fertilizer in increasing the growth, nodulation, and yield of soybeans. The following conclusions were therefore made from this finding:

It was also observed from the study that treatment combination of ash, nodumax and single super phosphate fertilizer were very effective in

increasing the height, number of leaves, pod , yield and nitrogen fixing ability of the soybeans varieties.

RECOMMENDATION

This finding was a milestone to Soybean farmers. It was therefore concluded that: The relatively medium to slightly acid condition of the soil with pH 5.5--6.3, means the soil of the study area is ideal for soybean cultivation. Soybean variety TGX-1935-3f has the tendency to grow early and produce good quality seeds and yield. The bio-fertilizer (Nodumax) in combination with other n fertilizer sources is an ideal substance that will initiate nodulation in soybean plant and increase its growth and yield,and fixing atmospheric nitrogen through symbiotic bacteria (rhizobium japonicum) in the root nodules.

CONTRIBUTION OF THE STUDY TO KNOWLEDGE

The availability of the Bio-fertilizer (Nodumax) in Nigeria means farmers and researchers can obtain the product at an affordable rate.

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