# 

INFLUENCE OF VARIETIES AND SSP RATES ON THE GROWTH PATTERNS OF BAMBARA GROUNDNUT (*Vigna subterranea* L. Verd.) IN GOMBE STATE NORTHEASTERN, NIGERIA

*ABSTRACT*

*Growth patterns of certain important underutilized crops like Bambara groundnut can be affected by* varietal variations *as well as nutrient supply rates. Field trials were conducted at the Teaching and Research Farm of the Faculty of Agriculture, Federal University of Kashere and at Tabra in the Sudan Savanna Agroecological Zone of Nigeria. The treatments consisted of two Bambara groundnut (white and red) varieties and five SSP rates (0, 20, 40, 60 and 80kg/ha). The treatments were laid out in a Randomized Complete Block Design (RCBD) with four replications. The plot size was 3 x 2m (6m2). Data collected on canopy height, number of leaves per plant, number of branches per plant, leaf area, number of days to 50% flowering, and number of nodules per plant, were subjected to Analysis of Variance, and mean separation done with LSD at 5% probability level. The result showed that no significant difference (P>0.05) existed among the varieties at both Tabra and Kashere in terms of nodules per plant. However, at Kashere only, SSP Rate at 80kg/ha produced the significantly highest value (6.63) over others, except SSP Rate at 60kg (6.08), whereas the control yielded the least number (4.10). Again, on days to 50% flowering, the red variety significantly (P<0.05) produced a higher mean at both Tabra and Kashere with 45.40% and 45.38% respectively over the white variety which produced a lower mean of 43.00% and 43.24% respectively at both locations. Meanwhile, at Keshere only, White variety significantly produced a higher mean on canopy height (28.16cm) over red variety (27.14cm). But SSP rate at 80kg/ha recorded the highest means on plant height at Tabra (23.86cm) and Keshere (31.83cm), including the mean value (27.86cm). The control treatment of no SSP applied, significantly produced a lower mean of at Tabra (19.63) and Keshere (23.05) with a mean of 22.57cm. On the number of leaves per plant, the two varieties showed no significant difference (P<0.05). However SSP rate at 80kg/ha produced the highest values (13.24leaves/plant) only at Keshere. In terms of Number of branches, Red variety recorded a significantly higher mean of (6.45) at Kashere only over white variety which produced a lower mean (4.77), and SSP rates did the same as SSP rate at 80kg/ha significantly (P<0.05) produced the highest value (6.38/plant) among others except SSP rate at 60kg/ha which gave 6.05/plant. Concerning Leaf Area, varieties did not produce any significant differences as against SSP rates. The control obtained significantly (P<0.05) the least value with 29.69cm2, compared to SSP rate at 80kg/ ha which produced a mean of 38.54cm2. Finally, Interaction effect was observed on branches as White variety with SSP rate at 60kg/ha, significantly produced a higher interaction effect (4.78) on branches closely followed by the same variety with SSP rate at 80kg/ha(4.75). In term of leaf area, White variety with SSP rate at 80kg/ha, significantly exacted a higher interaction effect of (36.15) whereas red variety with SSP rate at kg/ha produced the significantly least interaction effect (29.50).Variety and SSP rates interactions also showed significant differences on other parameters like days to 50% flowering, number of leaves/plant, canopy height.* From the results, *the white variety of Bambara Groundnut performed optimally better than the red variety in terms of growth parameters*. *Therefore, farmers in the study areas are recommended to adopt the White variety and 80 kg/ha of SSP rate for optimal growth of Bambara Groundnut.*

***Keyword****s****:*** *-**Bambara Groundnut, Variety, SSP, application, Tabra, Kashere and Growth.*

# 1.0 INTRODUCTION

Bambara groundnut (*Vigna subterranean* L.) belongs to the genus *Vigna* and family *Fabaceae*, it is a legume crop widely cultivated in Sub-Saharan Africa. Its Centre of origin is thought to be Bambara, near Timbuktu in Central Mali, West Africa hence its name Bambara groundnut (Nyamangara and Nyagumbo, 2010; Aliyu *et al*., 2016). The crop has also been widely cultivated in tropical regions since the seventeenth century and was also domesticated in the semi- arid zone of West Africa, probably around the head waters of the Niger River from where it spread in ancient times to Central Africa and more recently to the Madagascar Republic (Tweneboah, 2000; Boateng, 2006; Asante *et al*., 2021).

Generally, all fixed nitrogen goes directly into the plant. At the time it dies and decomposes the vegetative parts like roots, leaves, fruits, etc. release nitrogen into the soil. Returning most of the nitrogen in the soil is supplied to the nearest plants, the nitrogen in the legume will satisfy its nitrogen requirements. *Rhizobium* bacteria form a beneficial interaction with a legume crop to fix atmospheric nitrogen and convert it to ammonium for plant uptake. It improves the nodulation and also development of shoot: root with the effect of rhizobia inoculation. Soil microorganisms are involved in nitrogen cycling. Grain legumes increase the biological diversity in the ecosystem (Doku, 1995; Masawe *et al*., 2005). The seeds of Bambara groundnut contain sufficient quantities of protein (19%), carbohydrate (63%), fat (6.5%) and essential amino acids such as lysine, cysteine and methionine (Oliviera, 1976; Chai *et al*., 2017).

Thus, the crop produces a balanced food, high in protein content and as a source of plant protein for man (Cynthia, 2016; Effa *et al.*, 2016). The production of the crop in Sub-Saharan Africa is hindered by several factors such as drought, low soil fertility as well as restricted access to mineral fertilizers (Golli *et al*., 1995; Nyamangara and Nyagumbo, 2010). For successful crop production, SSP is considered as an essential mineral nutrient after nitrogen. SSP helps in root system and many aspects of plant physiology. On plant height, it was reported by Boateng (2006) that different levels of SSP have different effects on growth and yield of the crop.

In Nigeria, farmers are always faced with the problem of low soil fertility which has been considered as the most important constraint to crop yield and productivity (Odendo *et al*., 2004). Generally, nutrient management is a major aspect of cultural practices aimed at improvement of most crops (Nnadi *et. al*., 2025). Crop growth and yield development requires mineral nutrition at an appropriate amount which can be supplied to crops as a fertilizer. Application of SSP can therefore be a low cost alternative to alleviating low soil fertility on Bambara groundnut (Odendo *et al*., 2004). SSP fertilizer is a nutrient source for crop production (Harry *et al.*, 2011) and has been shown to increase soil available SSP (Heller *et al*., 1997).

When SSP is incorporated into the soil, it promotes transformation and mineralization of SSP, which results into higher SSP concentrations and higher total SSP uptake by plants (Heller *et al*., 1997). However, in Northern Nigeria, little is known is about the use of SSP fertilizers and their effects on crops especially Bambara groundnut for efficient utilization.

Studies indicate that significant variation among mung bean and cowpea genotypes has been reported for growth parameters like plant height, including number of pods per plant at low and adequate SSP levels (Balole *et al.,* 2003; Bamishaiye *et al*., 2011). This varied response to SSP application demonstrate the usefulness of this nutrient in promoting productivity of legumes as well as the need to grow suitably adapted cultivars to achieve optimal use of the limited resource. Meanwhile, in related a research, morphological attributes including number of leaves, plant height, number of branches and leaf area of cowpea were significantly improved due to the supplementation of SSP (Nweke and Emeh*,* 2013). Somta *et al.* (2011) assert that SSP requirements of the shoot and root tips are high due to increased metabolism and cell division occur at high rate.

Results of a certain study revealed that Bambara Groundnut (*Vigna subterranea*) has characteristics to grow in the marginal soil, tolerant into the drought condition and also has a potential of nitrogen fixation. Nitrogen is the key plant nutrient that stimulates root and shoot growth. SSP application significantly improves many aspects of plant physiology including photosynthesis, flowering, fruiting and maturation which ultimately result in better yield (Hasan *et al.*, 2018).

Adeyeye *et al*. (2019) conducted a trial on the effect of organic and inorganic Nutrient Sources on The Growth and Seed Yield of Bambara Groundnut (*Vigna Subterranean* (L) Variety in Wukari, Nigeria. Results showed that N fertilizer application rate of 30 kg N per hectare produced significant number of leaves, nodes, flowers and plant height.

Agyeman *et al.* (2022) conducted a trial on enhancing the productivity and sustainability of Bambara Groundnut (*Vigna subterranea* (L.) production using inorganic SSP fertilizer. Results showed that Bambara Groundnut genotypes had excellent performance based on growth and yield analysis, and the results indicated a positive significant interaction between landraces and SSP fertilizer rates. The biological suitability of 60 kg P205 per hectare increased the number of nodules per plant for Tiga Necuru, Kenya Capstone and Nav Red by 42.8%, 51.3% and 42.1% respectively, over control plots. The same for pod yield is 12%, 28% and 52% significantly higher than when SSP was applied at 45, 30 and 0 kg P205 per hectare, respectively.

Temegne *et al.* (2015) conducted trials on theeffect of phosphate deficiency on growth and SSP content of three Bambara Groundnut (*Vigna subterranea* (L.) varieties. Results obtained showed that from 1000 to 0µMPi, *Vigna subterranea* shoot fresh biomass reduced by 13.48%, 9.46% and 14.57% for varieties white variety and red variety, respectively. Its total fresh biomass also reduced by 8.29% for white variety, 3.32% for red variety and 6.94% for V3. But SSP deficiency (0 µM Pi) led to an increase in root fresh biomass (red variety: 8.82% and V3: 7.90%) and root/shoot ratio (white variety: 15.17%, red variety: 21.57% and V3: 25%).

Also according to Temegne *et al.* (2015), these results show a preferential allocation of biomass to the roots in SSP deficient plants. SSP deficiency had no significant effect on the number of emerged leaves and the plant water content of *Vigna subterranea*. However, it increased the specific leaf weight (0.027 for 0 µm SSP and 0.023gm/cm2 for 1000 µm SSP in white variety). The total leaves and roots SSP content of SSP deficient plants significantly decreased compared to non-deficient plants (1000). The SSP deficient plants showed better efficiency in SSP assimilation. White variety had the best vegetative growth, red variety showed highest SSP use efficiency and V3 contained more SSP in its organs.

The results further revealed that on days to flowering and maturity, the plant height, the number of branches and dry matter increased significantly at each level of SSP fertilizer. SSP is a vital element required for nodulation, stomatal regulation and photosynthesis in legume crops. SSP deficiency in tropical soils limits the growth and productivity of Bambara Groundnuts. The current study focused on determining the potential suitability of underutilized crops for food security using SSP fertilizer as soil amendment practice. Bambara Groundnut production at 0 kg SSP fertilizer rate might not be sufficient to enhance Bambara groundnut productivity significantly. The outcome of this study revealed the suitability of SSP fertilizer application in enhancing the sustainability of Bambara Groundnut productivity and the potential of Bambara Groundnut in diversifying crop production to ensure food security.

As a legume crop, Bambara groundnut of any variety can improve the soil fertility in varying degrees by nitrogen fixing bacteria present in the root nodules, but this alone cannot satisfy the nitrogen requirements of the plants (Chiezey *et al*., 1991). Nitrogen fixation by bacteria is essential for sustaining the growth, development, and yield of legumes (Bitire et al., 2023). Hence, there is the need for application of SSP to stimulate nodulation for optimum production (Toungos *et al.*, 2010). For enhanced growth, adequate supply of nitrogen is necessary as it has been found to be beneficial for promoting cell division and cell enlargement, among others (Shehu *et al.*, 2010). The judicious use of chemical fertilizers is also essential to maintain soil fertility (Vasilas *et al*., 1988). Bambara groundnut is usually grown with low input by subsistence farmers without fertilizer application in most of the farms and this makes its production to be marginal. Therefore, the broad objective of the present study is to determine influence of varieties and SSP rates on the growth patterns of Bambara groundnut (*Vigna subterranea* l. verd.) in Gombe State Northeastern, Nigeria. Specific objectives of the study are:-

1. to evaluate the effects of SSP rates on the growth of Bambara groundnut in the study areas.
2. to evaluate the effects of varieties on the growth of Bambara groundnut in the study areas.
3. to investigate the interaction effect of SSP rates and Bambara variety on its growth in the study area.
4. to ascertain the SSP rate most suitable for optimal growth of Bambara in the study area

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# 2.0 MATERIALS AND METHODS

# 2.1 Experimental Sites

Field trials were conducted during the 2023 rainy season at the Teaching and Research Farm of the Faculty of Agriculture, Federal University of Kashere and at Tabra in Gombe State North Eastern, Nigeria.

# 2.2 Treatments and Experimental Design

The two trials were factorially combined in a 2 x 5 and laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments consisted of two Bambara groundnut varieties (white and red) and five SSP rates of (0, 20, 40, 60 and 80kg per hectare). There were ten (10) plots and were replicated three times, making a total of thirty in the field. The plot size was 3 x 2m at as pacing of 50 x 50cm, with a 0.5m path between plots and 1m path between replications.

# 2.3 Agronomic Practices

The land was cleared manually using simple farm tools such as a cutlass, hand hoe and rake. The layout was designed and pegged using a hand hoe. Three seeds were sown per hole and later thinned to two plantsper stand after emergence. Weeding was done manually with the use of a hoe at 3, 6 and 9 weeks after sowing.

# 2.4 Data Collection

# *2.4.1 Soil analysis*

Initial nutrient status of the experimental sites was assessed before designing the experiment, three portions was selected randomly at two soil depths; 0-15 and 15-30 cm to give a composite soil sample. Thereafter, the samples were analyzed to determine the physical and chemical analysis of the experimental site.

# *2.4.2 Canopy height (cm)*

Canopy height was measured from the base of the plant to the end from the five sampled plants in each treatment using a measuring tape graduated in cm, the average taken and recorded.

# *2.4.3 Number of leaves per plant*

Total number of leaves per plantfrom the five sampled plants in each treatment was obtained by physical counting, the average taken and recorded.

# *2.4.4 Number of branches per plant*

Total number of branches per plantfrom the five sampled plants in each treatment was obtained by physical counting, the average taken and recorded.

# *2.4.5 Leaf area (cm2)*

Leaf area (cm2) was measured manually from the five sampled plants in each treatment and the average was taken and recorded. Measurement was done by determining the leaf length and breadth and was multiplied by a factor of 0.80 (constant).

# *2.4.6 Days to 50 % flowering*

Days to 50% flowering were the number of days when 50% of plants in each treatment have flowered.

# *2.4.7 Number of nodules per plant*

Number of nodules per plant was obtained by physical counting of the number of nodules in each treatment using a destructive sample, the average taken and recorded.

# 2.5 Data Analysis

Data collected was analyzed using analysis of variance (ANOVA). Means was separated using the least significant difference at 5% level of probability (Gomez and Gomez, 1984).

3.0 **RESULTS**

# *3.1 Canopy height (cm) and number of leaves per plant*

Table 1 shows the effects of varieties and SSP rates on canopy height at Tabra, Kashere and the mean. The results revealed that there was no significant difference (P>0.05) among the varieties of Bambara groundnut on canopy height at Tabra and the mean, however there was a significant difference (P<0.05) at Kashere. White variety significantly produced a higher mean on canopy height of (28.16) over red variety which produced a lower mean of (27.14). There was also a significant difference (P<0.05) among the SSP rates on canopy height at Tabra, Kashere and the mean. The control treatment of no SSP applied, significantly produced a lower mean of (19.63, 23.05 and 22.57), followed by SSP rate at 20kg per hectare which produced means of (20.51, 25.91 and 23.21), followed by SSP rate at 40kg per hectare which produced means of (21.98, 27.67 and 24.83), followed by SSP rate at 60kg per hectare which produced means of (22.53, 29.33 and 25.93) and SSP rate at 80kg per hectare produced the highest means on plant height of (23.86, 31.83 and 27.86).

The results in Table 1 also shows that there was no significant difference (P>0.05) among the varieties of Bambara groundnut on the number of leaves per plant at Tabra, Kashere and the mean (Table 1). There was also no significant difference (P>0.05) at Gombe among the SSP rates on the number of leaves per plant. However, there was a significant difference among the SSP rates on the number of leaves per plant at Kashere and the mean. The control treatment of no SSP applied, significantly produced a lower mean of (9.27 and 10.19), followed by SSP rate at 20kg per hectare which produced means of (10.10 and 10.73), followed by SSP rate at 40kg per hectare which produced means of (11.63 and 11.51), followed by SSP rate at 60kg per hectare which produced means of (12.24 and 11.35) and SSP rate at 80kg per hectare produced the highest means on number of leaves per plant of (13.24 and 11.35).

Table 1: Effects of varieties and SSP Rates on Plant Height (cm) and Number of Leaves per Plant of Bambara Groundnut (*Vigna subterranea* L.) at Tabra, Kashere and Mean in Gombe State, Nigeria

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Treatments | Canopy Height (cm) | | | Number of Leaves per Plant | | |
| Variety (V) | Tabra | Kashere | Mean | Tabra | Kashere | Mean |
| White variety | 21.76 | 28.16 | 24.96 | 11.22 | 10.70 | 10.96 |
| Red variety | 21.65 | 27.14 | 24.40 | 11.18 | 11.90 | 11.54 |
| LSD | 1.014 | 0.810 | 0.912 | 1.157 | 2.503 | 1.830 |
| SSP Rates (kg) per Hectare |  |  |  |  |  |  |
| 0 | 19.63 | 23.50 | 22.57 | 11.10 | 9.27 | 10.19 |
| 20 | 20.51 | 25.91 | 23.21 | 11.35 | 10.10 | 10.73 |
| 40 | 21.98 | 27.67 | 24.83 | 11.38 | 11.63 | 11.51 |
| 60 | 22.53 | 29.33 | 25.93 | 10.46 | 12.24 | 11.35 |
| 80 | 23.86 | 31.83 | 27.86 | 11.72 | 13.24 | 12.48 |
| LSD (0.05) | 1.604 | 1.282 | 1.443 | 1.830 | 2.101 | 1.965 |
| Interaction |  |  |  |  |  |  |
| V x P | NS | 1.270 | NS | NS | 1.345 | NS |

## LSD = Least Significant Difference at 5% Level of Probability

# *3.2 Interaction between varieties with SSP rates on canopy height (cm) at Kashere*

Table 2 shows the interaction between varieties with SSP rates at Kashere in Sudan savanna agro-ecologicla zone of Nigeria on canopy height of Bambara Groundnut. White variety with SSP rate at 80kg per hectare, significantly produced a higher interaction of (31.85), followed by red variety with SSP rate at 80kg per hectare which produced a significant interaction of (31.81), followed by white variety with SSP rate at 60kg per hectare which produced a significant interaction of (29.81), followed by white variety with SSP rate at 60kg per hectare which produced a significant interaction of (28.84), followed by white variety with SSP rate at 40kg per hectare which produced a significant interaction of (28.33), followed by red variety with SSP rate at 40kg per hectare which produced a significant interaction of (27.00), followed by white variety with SSP rate at 20kg per hectare which produced a significant interaction of (26.82), followed by red variety with SSP rate at 20kg per hectare which produced a significant interaction of (25.00), followed by white variety with SSP rate at 0kg per hectare which produced a significant interaction of (23.95) and followed by red variety with SSP rate at 0kg per hectare which produced a significant interaction of (23.05).

Table 2: Interaction Between Varieties with SSP Rates on Canopy Height (cm) of Bambara Groundnut (*Vigna subterranea* L) at Kashere in Gombe State, Nigeria

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SSP Rates  (kg) per Hectare | 0 | 20 | 40 | 60 | 80 |
| Variety |  |  |  |  |  |
| White variety | 23.95 | 26.82 | 28.33 | 29.81 | 31.85 |
| Red variety | 23.05 | 25.00 | 27.00 | 28.84 | 31.81 |
| LSD |  |  | 1.270 |  |  |

## LSD = Least Significant Difference at 5% Level of Probability

# *3.3 Interaction between varieties and SSP rates on number of leaves per plant at Kashere*

Table 3 shows the interaction between varieties with SSP rates at Kashere in Sudan savanna agro-ecological zone of Nigeria on the number of leaves per plant. Red variety with SSP rate at 80kg per hectare, significantly produced a higher interaction of (14.26), followed by red variety with SSP rate at 60kg per hectare which produced a significant interaction of (12.61), followed by white variety with SSP rate at 80kg per hectare which produced a significant interaction of (12.18), followed by white variety with SSP rate at 60kg per hectare which produced a significant interaction of (11.86), followed by red variety with SSP rate at 40kg per hectare which produced a significant interaction of (11.67), followed by white variety with SSP rate at 40kg per hectare which produced a significant interaction of (11.38), followed by red variety with SSP rate at 0kg per hectare which produced a significant interaction of (10.71), followed by red variety with SSP rate at 20kg per hectare which produced a significant interaction of (10.00), followed by white variety with SSP rate at 20 kg per hectare which produced a significant interaction of (9.49) and followed by white variety with SSP rate at 0 kg per hectare which produced a significant interaction of (8.54).

Table 3: Interaction Between Varieties with SSP Rates on Number of Leaves per Plant of Bambara Groundnut (*Vigna subterranea* L) at Kashere in Gombe State, Nigeria

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SSP Rates  (kg) per Hectare | 0 | 20 | 40 | 60 | 80 |
| Variety |  |  |  |  |  |
| White variety | 8.54 | 9.49 | 11.38 | 11.86 | 12.18 |
| Red variety | 10.71 | 10.00 | 11.67 | 12.61 | 14.26 |
| LSD |  |  | 1.345 |  |  |

## LSD = Least Significant Difference at 5% Level of Probability

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# *3.4 Number of branches per plant and leaf area (cm2)*

Table 4 shows the effect variety and SSP rates on the number of branches per plant of Bambara groundnut in the Sudan savanna agroecological zone of Nigeria. There was no significant difference (P>0.05) among the varieties at Tabra and the mean. However, there was a significant difference (P<0.05) at Kashere on the number of branches per plant. Red variety significantly produced a higher mean of (6.45) over white variety which produced a lower mean of (4.77). There was also no significant difference (P>0.05) among the SSP rates at Tabra and the mean. However, there was a significant difference (P<0.05) at Kashere on the number of branches per plant. The control treatment of no SSP applied, significantly produced a lower mean of (4.58), followed by SSP rate at 20kg per hectare which produced a mean of (5.50), followed by SSP rate at 40kg per hectare which produced a mean of (5.55), followed by SSP rate at 60 which produced a mean of (6.05) and SSP rate at 80 kg per which produced a mean of (6.38), but were not significantly different from SSP rate at 60kg per hectare.

Table 4 also displays the effect variety and SSP rates on leaf area per plant of Bambara groundnut in the Sudan savannah agro-ecological zone of Nigeria. There was no significant difference (P>0.05) among the varieties at Tabra, Kashere and the mean on leaf area per plant. There was also no significant difference (P>0.05) among the SSP rates at Gombe and the mean leaf area per plant. However, there was a significant difference (P<0.05) at Kashere on leaf area per plant. The control treatment of no SSP applied, significantly produced a lower mean of (29.69), followed by SSP rate at 20kg per hectare which produced a mean of (30.53), followed by SSP rate at 40kg per hectare which produced a mean of (32.31), followed by SSP rate at 60kg/ha which produced a mean of (34.07) and SSP rate at 80kg per hectare which produced a mean of (38.54).

Table 4: Effects of Varieties and SSP Rates on Number of Branches per Plant and Leaf Area (cm2) Per plant of Bambara Groundnut (*Vigna subterranea* L.) at Tabra, Kashere and Mean in Gombe State, Nigeria

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Treatments | Number of Branches per Plant | | | Leaf Area (cm2) | | |
| Variety (V) | Tabra | Kashere | Mean | Tabra | Kashere | Mean |
| White variety | 4.18 | 4.77 | 4.48 | 33.07 | 32.91 | 32.99 |
| Red variety | 4.34 | 6.45 | 5.40 | 31.02 | 31.94 | 31.48 |
| LSD | 0.365 | 0.779 | 0.572 | 2.120 | 2.314 | 2.217 |
| SSP Rates (kg)  per Hectare |  |  |  |  |  |  |
| 0 | 4.13 | 4.58 | 4.36 | 30.20 | 29.69 | 29.95 |
| 20 | 4.15 | 5.50 | 4.83 | 31.20 | 30.53 | 30.37 |
| 40 | 4.09 | 5.55 | 4.82 | 31.80 | 32.31 | 32.06 |
| 60 | 4.32 | 6.05 | 5.19 | 33.00 | 34.07 | 33.54 |
| 80 | 4.62 | 6.38 | 5.50 | 35.81 | 38.54 | 37.18 |
| LSD | 0.577 | 1.231 | 0.904 | 3.590 | 3.659 | 3.625 |
| Interaction |  |  |  |  |  |  |
| V x P | 0.074 | NS | NS | NS | 1.450 | NS |

## LSD = Least Significant Difference at 5% Level of Probability

# *3.5 Interaction between varieties with SSP rates on number of branches per plant at Tabra*

Table 5 shows the interaction between varieties and SSP rates at Tabra in Sudan savanna agroecological zone of Nigeria on the number of branches per plant at Tabra. White variety with SSP rate at 60kg per hectare, significantly produced a higher interaction of (4.78), followed by white variety with SSP rate at 80 kg per hectare which produced a significant interaction of (4.75), followed by red variety with SSP rate at 0kg per hectare which produced a significant interaction of (4.59), followed by red variety with SSP rate at 80kg per hectare which produced a significant interaction of (4.48), followed by red variety with SSP rate at 20kg per hectarewhich produced a significant interaction of (4.46), followed by red variety with SSP rate at 40 kg per hectare which produced a significant interaction of (4.30), followed by white variety with SSP rate at 40kg per hectare which produced a significant interaction of (3.87), followed by red variety with SSP rate at 60 kg per hectare which produced a significant interaction of (3.86), followed by white variety with SSP rate at 0kg per hectare which produced a significant interaction of (3.67) and followed by white variety with SSP rate at 20kg per hectare which produced a significant interaction of (3.63).

Table 5: Interaction Between Varieties with SSP Rates on Number Branches per Plant of Bambara Groundnut (*Vigna subterranea* L) at Tabra in Gombe State, Nigeria

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SSP Rates  (kg) per Hectare | 0 | 20 | 40 | 60 | 80 |
| Variety |  |  |  |  |  |
| White variety | 3.67 | 3.63 | 3.87 | 4.78 | 4.75 |
| Red variety | 4.59 | 4.46 | 4.30 | 3.86 | 4.48 |
| LSD |  |  | 0.074 |  |  |

## LSD = Least Significant Difference at 5% Level of Probability

# *3.6 Interaction between varieties with SSP rates on leaf area (cm2) at Kashere*

Table 6 shows the interaction between varieties and SSP rates at Kashere in Sudan savanna agroecological zone of Nigeria on leaf area at Kashere. White variety with SSP rate at 80kg per hectare, significantly produced a higher interaction of (36.15), followed by red variety with SSP rate at 80kg per hectare which produced a significant interaction of (34.92), followed by white variety with SSP rate at 60kgper hectare which produced a significant interaction of (34.91), followed by red variety with SSP rate at 60kg per hectare which produced a significant interaction of (33.23), followed by white variety with SSP rate at 40kg per hectare which produced a significant interaction of (32.72), followed by red variety with SSP rate at 40kg per hectare which produced a significant interaction of (31.89), followed by white variety with SSP rate at 20kg per hectare which produced a significant interaction of (30.90), followed by red variety with SSP rate at 20kgper hectare which produced a significant interaction of (30.16), followed by white variety with SSP rate at 0kg per hectare which produced a significant interaction of (29.88) and followed by red variety with SSP rate at 0kg per hectare which produced a significant interaction of (29.50).

Table 6: Interaction Between Varieties with SSP Rates on Leaf Area (cm2) of Bambara Groundnut (*Vigna subterranea* L) at Kashere in Gombe State, Nigeria

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SSP Rates  (kg) per Hectare | 0 | 20 | 40 | 60 | 80 |
| Variety |  |  |  |  |  |
| White variety | 29.88 | 30.90 | 32.72 | 34.91 | 36.15 |
| Red variety | 29.50 | 30.16 | 31.89 | 33.23 | 34.92 |
| LSD |  |  | 1.450 |  |  |

**LSD = Least Significant Difference at 5% Level of Probability**

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# *3.7 Number of nodules per plant and days to 50% flowering*

Table 7 shows the effects varieties and SSP rates on the number of nodules per plant of Bambara groundnut in the Sudan savanna agroecological zone of Nigeria. There was no significant difference (P>0.05) among the varieties at Tabra, Kashere and the mean on the number of nodules per plant. There was also no significant difference (P>0.05) among the SSP rates at Tabra and the mean. However, there was a significant difference (P<0.05) at Kashere on the number of nodules per plant. The control treatment of no SSP applied, significantly produced a lower mean of (4.10), followed by SSP rate at 20kg per hectare which produced a mean of (4.50), followed by SSP rate at 4kg per hectare which produced a mean of (5.71), followed by SSP rate at 60 which produced a mean of (6.08) and SSP rate at 80kg per hectare which produced a mean of (6.63), but were not significantly different from SSP rate at 60kg per hectare.

Table 7 also shows the effect of variety and SSP rates on days to 50% flowering of Bambara groundnut in the Sudan savanna agroecological zone of Nigeria. There was a significant difference (P<0.05) among the varieties at Tabra and Kashere, but no significant difference on the mean. At Tabra and Kashere, red variety significantly produced a higher mean of (45.40 and 45.38) over white variety on days to 50% flowering which produced a lower mean of (43.00 and 43.24). There was also no significant difference (P>0.05) among the SSP rates at Tabra, Kashere and the mean on days to 50% flowering.

Table 7: Effects of Varieties and SSP Rates on Number of Nodules per Plant and Days to 50% Flowering of Bambara Groundnut (*Vigna subterranea* L.) at Tabra and Kashere in Gombe State, Nigeria

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Treatments | Number of Nodules per Plant | | | Days to 50% Flowering | | |
| Variety (V) | Tabra | Kashere | Mean | Tabra | Kashere | Mean |
| White variety | 2..04 | 5.24 | 3.64 | 43.00 | 43.24 | 43.12 |
| Red variety | 2.24 | 5.58 | 3.91 | 45.40 | 45.38 | 45.39 |
| LSD | 0.410 | 0.734 | 0.572 | 2.089 | 2.069 | 2.079 |
| SSP Rates (kg)  per Hectare |  |  |  |  |  |  |
| 0 | 2.33 | 4.10 | 3.22 | 42.90 | 42.84 | 42.87 |
| 20 | 2.48 | 4.52 | 3.50 | 43.58 | 43.52 | 43.55 |
| 40 | 2.70 | 5.71 | 4.21 | 44.86 | 44.35 | 44.61 |
| 60 | 2.84 | 6.08 | 4.46 | 45.26 | 44.80 | 45.03 |
| 80 | 3.10 | 6.63 | 4.87 | 47.18 | 46.07 | 46.63 |
| LSD | 0.430 | 1.160 | 0.795 | 3.124 | 3.303 | 3.214 |
| Interaction |  |  |  |  |  |  |
| V x P | NS | NS | NS | NS | 2.321 | NS |

**LSD = Least Significant Difference at 5% Level of Probability**

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# *3.8 Interaction between varieties with SSP rates on days to 50% flowering at Kashere*

Table 8 shows the interaction between varieties with SSP rates at Kashere in Sudan savanna agroecological zone of Nigeria on days to 50% flowering at Kashere. Red variety with SSP rate at 80kg per hectare, significantly produced a higher interaction of (46.25), followed by red variety with SSP rate at 60kg per hectare which produced a significant interaction of (45.90), followed by white variety with SSP rate at 80kg per hectare which produced a significant interaction of (45.89), followed by red variety with SSP rate at 40kg per hectare which produced a significant interaction of (45.55), followed by red variety with SSP rate at 20kg per hectare which produced a significant interaction of (45.07), followed by red variety with SSP rate at 0kg per hectare which produced a significant interaction of (44.20), followed by white variety with SSP rate at 60kg per hectare which produced a significant interaction of (43.70), followed by white variety with SSP rate at 40kg per hectare which produced a significant interaction of (43.15), followed by white variety with SSP rate at 20kg per hectare which produced a significant interaction of (41.97) and followed by white variety with SSP rate at 0kg per hectare which produced a significant interaction of (41.46).

Table 8: Interaction Between Varieties with SSP Rates on Days to 50% Flowering of Bambara Groundnut (*Vigna subterranea* L) at Kashere in Gombe State, Nigeria

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SSP Rates  (kg) per Hectare | 0 | 20 | 40 | 60 | 80 |
| Variety |  |  |  |  |  |
| White variety | 41.46 | 41.97 | 43.15 | 43.70 | 45.89 |
| Red variety | 44.20 | 45.07 | 45.55 | 45.90 | 46.25 |
| LSD |  |  | 2.321 |  |  |

## LSD = Least Significant Difference at 5% Level of Probability

**4.0 DISCUSSION**

Plant height was observed to have increased linearly with increasing application of SSP relative to the control treatment. The role of SSP in plant photosynthesis, biological nitrogen fixation of legumes and crop maturation investigated confirmed that application of SSP decreased maturity days. Cultivation of various genotypes of Bambara Groundnut has become one of the strategies to escape drought and enhance food security. Because of the relatively prolonged maturity days, application of SSP to Bambara Groundnut is partially, a significant means of reducing maturity days. Previous studies have reported similar relations between plant height and increasing SSP application for different leguminous species including Bambara Groundnut, soybean and cowpea.

In this study, the increased plant height associated with increasing SSP rates might have resulted from SSP ability to regulate enzymatic reactions leading to the enhancement of plant metabolism and formation of new cells and consequently increasing stem length. The control plants produced the shortest plants as they had to rely on the native soil fertility which from the result of the chemical analysis was deficient in nutrients. The white variety of Bambara Groundnut performed optimally better than the red variety in terms of plant height. Number of leaves per plant was significantly higher among the two varieties of Bambara Groundnut, with the white variety producing more leaves than the red one. This observation is similar to the findings of Boudion and Mergeai (2001); Azman-Ali (2001); Balole *et al*. (2003); Bamishaiye *et al.* (2011); Aliyu *et al*. (2016); Asante *et al*. (2021) who reported that there exist varietal variations among Bambara Groundnut genotypes with some performing much better than others in terms growth.

The positive response of Bambara groundnut varieties to SSP nutrition could be attributed to the stimulatory effect of SSP on growth hormones and its ability to induce early flowering in Bambara groundnut. These differences in the observed reduction in flowering days as influenced by SSP could confirm the influence of environmental conditions on growth and development of Bambara groundnut. The results agree with the findings of Coudert (1984); Doku (1995); Ellah and Singh (2008); Cynthia (2016); Chai *et al.* (2017) who reported that SSP application reduced number of days to 50% flowering compared to the untreated plots. In terms of the SSP rates, 80kg SSP significantly gave higher growth parameters over the rest of the treatments with the control of no SSP applied giving the least canopy height and number of leaves per plant. These observations are similar to the findings of Chiezey *et al.* (1991); Akombo and Asema (2013); Effa *et al*. (2016); Adeyeye *et al.* (2019) who reported that the performances of Bambara Groundnut are enhanced greatly by the application of SSP.

**5.0 CONCLUSION**

Growth patterns of certain important crops like Bambara groundnut can be affected by varietal variations as well as nutrient supply rate.

White variety and SSP rate at 80 kg per hectare gave the best result in terms of monitored growth parameters like canopy height, number of leaves per plant, number of branches per plant, leaf area, number of days to 50% flowering, and number of nodules per plant. In terms of leaf area, White variety with SSP rate at 80 kg/ha, significantly exacted a higher interaction effect of (36.15) whereas red variety with SSP rate at 0 kg/ha produced the significantly least interaction effect (29.50).Variety and SSS rates interactions also showed significant differences on other parameters like days to 50% flowering, number of leaves/plant, canopy height. Finally, from the results, the white variety of Bambara Groundnut performed optimally better than the red variety in terms of growth parameters. Therefore, farmers in the study areas are recommended to adopt the White variety and 80 kg/ha of SSP rate for optimal growth of Bambara Groundnut.

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