



INFLUENCE OF INTRA-ROW SPACING ON THE GROWTH AND YIELD OF GREEN BEAN (*Phaseolus vulgaris* L.) VARIETIES IN BAUCHI STATE, NIGERIA

Bako, A., Sabo M. U., and Amba A. A.

Department of Crop Production, Faculty of Agriculture and Agricultural Technology,
Abubakar Tafawa Balewa University, Bauchi, Nigeria

Corresponding email: auwalubako@gmail.com

ABSTRACT

Field experiment was conducted during the rainy season of 2023 and 2024 at the teaching and Research farm, Gubi campus, Abubakar Tafawa Balewa University, Bauchi (10°22'N and 9° 47'E) to determine the Influence of intra row spacing on the growth and yield components of green bean varieties in Bauchi state Nigeria. The treatment consisted of three varieties of green bean (maiaduwa, royal, banana), three intra row spacing (30cm, 40cm, 50cm). These were factorially combined to give nine (9) treatment combinations and were laid out in randomized complete block design (RCBD) with three replication. Data were collected on plant height, number of leaves, leaf area, number of branches, days to 50% flowering, 100 seed weight, number of pod per plant, number of seed per pod, pod weight per plot, seed yield per plot and total yield per hectare. All data collected were subjected to analysis of variance (ANOVA) significantly difference means were separated by using Duncan multiple range test (DMRT). The result indicated significant ($p \leq 0.05$) variation among all the three varieties on almost all the growth and yield parameters tested across both trials and few significant difference on the effect of intra row spacing. Effect of variety showed that, Royal recorded the tallest plant height (124.48cm&123.59cm) at advanced stage of growth. Banana gave the highest number of leaves (20.77&21.72) at 3WAS. On leaf area maiaduwa and royal recorded the largest leaf area compared to banana bean. On the number of branches, royal recorded the overall value in the advanced stage of growth (9WAS) better than maiaduwa and banana. However, the highest value for number of pod per plant (25.3&26.0), number of seed per pod (70.6&52.7), seed yield per plot (306.9&248) and total yield per hectare (7.41t/ha & 6.34t/ha) was recorded by maiaduwa and royal across the two cropping season. While Banana outperformed other varieties for days to 50% flowering and 100 seed weight respectively. Intra row spacing showed no much effects on most of the parameters measured except on plant height (3WAS), days to 50% flowering and number of pod per plant. Therefore, Maiaduwa and royal variety of green bean in combination with 30cm and 40cm intra row spacing can be adopted by growers as suitable variety and better intra row spacing in the study area. Further study should be carried out to ascertain these findings and make strong recommendation.

Keywords: Green bean, varieties, intra-row spacing, growth and yield components

INTRODUCTION

Meeting the food demand of the projected 9.8 billion population in 2050 and at the same time achieving the second of the Sustainable Development Goals by the United Nations of ending hunger, achieving food security, improved nutrition and promote sustainable agriculture, there is a need for sustainable increases in crop yield and the exploration of underutilized or neglected crops, particularly grain legumes, which offer dual benefits as food sources and soil fertility enhancers (UN 2015). Green bean (*Phaseolus vulgaris*) is a high-value leguminous crop known for its rich nutritional content and economic potential. It is widely cultivated in temperate and tropical regions; however, its production remains limited in Bauchi State due to environmental and agronomic constraints. Despite its benefits, green bean farming has not been extensively explored in this region, creating a gap in knowledge regarding its adaptability and yield performance under Bauchi's agro-ecological conditions. It is among the leguminous crop that is underutilized both in terms of cultivation and consumption, especially in west Africa at large Nigeria in particular. It is also known as the common bean, French bean, snap bean, string bean, pinto bean etc., (Bala *et al*, 2023). Green bean is globally cultivated annually on nearly 1.5 million hectares (ha) of land to produce about 20.7 million metric tons of fresh



beans yield with an average yield of 13.5 t ha⁻¹, its production in Africa was 0.6 million metric tons cultivated on 71341 ha giving an average of 9.0t (Dauda *et al.*, 2016). Its consumption both in fresh, dried and processed form has tended to increase latterly due to its nutritional value, simple cultivation technology, excellent storage properties and its wide range of culinary uses. In addition, their high content of carbohydrates, fiber, some minerals and vitamins make beans an excellent nutrient source, Green beans though a day neutral vegetable crop, it responds differently to sowing time and yield variation have been reported with different sowing spacing (Bala *et al.*, 2022). Green bean is utilized in numerous ways; the leaves is occasionally used as a vegetable, while the straw is used for fodder. Its flour is used at 50% inclusion with wheat flour for the production of protein and mineral rich cookies (Bala *et al.*, 2023). In Africa, the young leaves are consumed as source of vitamin A, while in parts of South America the roasted seed is consumed, receiving the name pop 'bean (Gonzalez *et al.*, 2014). In Nigeria, it is mostly used to garnish fried rice and also used to prepare soup, source and salad. Green Bean has been reported to have many nutritional and medicinal value due to the presence of anti-oxidants, such as quercetin, which inhibit oxidation by scavenging free radicals in living cells as such it is referred to as a functional food item. As a leguminous crop, it is known to improve soil fertility. (Anderson and Bow land, 2001).

The characteristics of different common bean varieties are different each other in terms of their growth habit, days to maturity, seed color, seed size, and seed weight, and agro ecological adaptation. The seed size of *Phaseolus vulgaris* varies considerably, but most commercial cultivars of common beans have a seed size in the range of 200 to 350 mg (Masa *et al.*, 2017). Spatial arrangement of the plant directly or indirectly affects the production potential of common bean varieties. Thus, there is no site and variety specific recommendation on the plant spacing of common bean varieties. In view of the above facts the present investigation was undertaken with the objective to assess the effects of inter and intra row spacing on yield and yield related traits of common bean varieties (Amany, 2014). Despite the numerous importance of green beans to nutrition, health and economy increase in its demand and cultivation, its yield stagnates in the range of 5-8t/ha as against the expected potential yield of 15-20t/ha. This is attributed to the use of low yielding varieties, lack of knowledge of the optimum sowing dates, poor fertilization and low nutrient status of our soils among others. Adequate knowledge of its cultivation is lacking most especially in terms of selection for high yielding varieties, appropriate recommended intra row spacing plant nutrition for good yield. Research findings revealed variation in growth and yield of different types of varieties, with most varieties yielding below their potential yield. This study represents the first attempt to evaluate the adaptability and yield performance of three green bean varieties Maiaduwa, Royal, and Banana in Bauchi State. These varieties, originally sourced from Jos, Plateau State, will be assessed for their growth potential in this new environment. The findings will provide valuable insights into the feasibility of green bean cultivation in the Northern Guinea Savannah, offering farmers an alternative high-value crop to enhance food security and income generation.

MATERIALS AND METHODS

Field experiment was conducted at the teaching and research farm of Abubakar Tafawa Balewa University, Gubi Campus Bauchi (10° 22'N and 9° 47'E) and 609.3m above sea level located at the Northern Guinea Savannah agro ecological zones of Nigeria. The trial was carried out during the rainy seasons of 2023 and 2024. The materials for the experiment consisted of three seeds of green bean (Banana, Maiaduwa and Royal) and Maiaduwa is a determinate variety (otherwise called bush type) with erect growth habit that matures in 60-75days. The seed color is white and seed shape is oval. It is mostly grown in Jos Plateau State. Royal and banana are mostly determinate varieties with erect growth habits. The seeds are white and oval in shape but seed size is a bit bigger than that of banana. They matures in 60-75days. Banana was obtained from Agricultural seed/skills and training center Jos, Plateau State. While royal and banana obtained from farmers in Bokkos local government plateau state. The treatments consisted of three Varieties (Banana, Maiaduwa, and Royal) and three intra row spacing (30cm, 40cm, 50cm). The inter row spacing was set at 30cm in all the plots. Treatments were factorially combined to give nine (9) treatment combinations and were laid out in a randomized



complete block design (RCBD) with three replications total of 27 plots. Basins size of 3m x 3m was constructed using hoe which serves as a seed bed. The distance maintained between the individual unit plots was 0.5m and that between the replication was 1.0m. A total area of 31mx11m (341m²) were earmarked as experimental field. Green bean seeds were treated with apron star (methylthiuram plus matalaxyl plus carboxin) at the rate of 10 g sachet of chemical per 3.0 kg of seeds before sowing. This was carried out to avoid soil borne pests and diseases. The land was ploughed, disked and leveled manually. The field was cleared from all unwanted materials and layout was prepared against soil fertility gradient and slope. The field layout was prepared, divided in to blocks, and again each blocks divided into plots. After randomization of treatment was done, the proposed intra row spacing prepared. Two seeds per hole were sown and thinned one plant per hill two weeks after sowing throughout the plots. All other necessary agronomic management practices were carried out uniformly as the recommendation.

The crop was weeded twice manually. First weeding was done at three weeks after sowing (WAS), second weeding done at six weeks after sowing WAS. Demarcation, boundaries and drainage channels were also kept weed free. The green bean plant were attacked by thrips (*Taeniothrips sjostedti*) at flowering stage and physiological maturity. The damage results in blooms falling off and affects the formation of pods. The insect are yellow when immature and dark brown when adult. It is extremely small 1-2mm maximum. It feeds on flower and causes damages to young developing pods. The surface of these pods were rough with silver spots. Damage of thrips can range between 10-36% of pod yield (Duff *et al.*, 2015). Full cover was sprayed with a cypermethrin insecticide at the rate of one liter (1) per hectare using 16 liter knapsack sprayer. This was repeated after one week to get rid of all insect population in the research field. A composite soil sample were collected from the experimental field and were analyzed in the laboratory for physico-chemical properties. Data were collected on growth phenology, yield and yield components of green beans. All data collected were subjected to analysis of variance ANOVA using Statistical software Gen Stat 64-bit Release 17.1 .Significantly different means were separated by DMRT

RESULTS AND DISCUSSION

Plant Height

Table 1: presented the influence of variety and intra row spacing on plant height of green bean at different growth stage during 2023 and 2024 rainy season. The result revealed significant effect of variety on plant height at 3WAS ranged from 14.41cm to 20.77cm where maiadua recorded the tallest plant height. At 9WAS the result revealed the significant ($P \leq 0.05$) difference of plant height among the varieties with royal recorded the tallest with 124.84cm during 2023 season. The result agreed with Kenneth (2012) who reported significant differences among six green bean varieties evaluated on plant height. Meanwhile the result revealed significant ($P \leq 0.05$) differences among the intra row spacing at 3WAS with 40cm recorded the highest plant height followed by 50cm. There was no effect of intra row spacing at 6WAS and 9WAS. The result is against the findings of Masa *et al.* (2017) who reported the narrow intra row spacing of 7cm resulted in highest increase in plant height. The result of the interaction indicated that, no effect of variety and intra row spacing across all sampling periods in 2023 season.

During 2024 season, the result further revealed a significant effect of variety at 3WAS and 9WAS.maiadua recorded the tallest of the plant height followed by royal at 3WAS and 9WAS respectively during 2024 season. The result further revealed significant ($P \leq 0.05$) difference among intra row spacing at 3WAS where 40cm recorded the tallest plant height followed by 50cm and 30cm. this result was against the findings of Gemechu and Solomon (2021) who reported that tallest plant (59.35cm) was recorded at 5cm intra row spacing while the shortest plant height was (53.33) was observed at 15cm intra row spacing. Mitiku (2017) also reported significant differences due to the variation of spacing in green beans. However, there was no effect of intra row spacing recorded at 6WAS and 9WAS. Result further revealed no interaction effect between variety and intra row spacing throughout the sampling periods of 2024 season. Therefore, 2023 season recorded the overall plant height and that can be attributed to variation of weather factors most especially temperature, relative



humidity and differences in genotype. The significantly taller plants obtained from maiaduwa and royal better than banana indicates the genetic differences that exists between the three varieties in their ability to utilize growth resources in the environment efficiently which lead to better performance in term of plant height. This result lends support to the observation of Getachew *et al*, (2014) who reported variation in growth characters on green bean varieties.

Table 1: Influence of Variety and Intra Row Spacing on Plant Height (cm) of Green Bean during the Rainy Season in Bauchi State

Treatments	Weeks after sowing (WAS) 2023			2024		
	3	6	9	3	6	9
Variety						
Banana	14.41 ^b	35.2	66.21 ^b	12.23 ^c	32.6	65.54 ^b
Maiaduwa	20.77 ^a	39.5	40.07 ^b	19.96 ^a	35.5	39.19 ^b
Royal	16.65 ^b	58.8	124.48 ^a	15.29 ^b	55.9	123.59 ^a
LS	**	NS	**	**	NS	**
SE±	1.430	11.7	25.5	1.273	11.32	25.5
Intra row spacing (cm)						
30	14.65 ^b	46.4	68	13.77 ^b	42.4	68
40	19.51 ^a	49.4	87	18.54 ^a	45.8	86
50	17.67 ^{ab}	37.6	75	15.18 ^b	35.8	75
LS	**	NS	NS	**	NS	NS
SE±	1.430	11.07	25.5	1.273	11.32	25.5
Interaction						
VxS	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) in a row are statistically similar by DMRT, LS level of significance, SE+ standard error , ** significant at 0.01 probability level , NS not significant.

Number of Leaves

Table 2: presented the influence of variety and intra row spacing on number of leaf of green bean in Bauchi at different growth stages during 2023 and 2024 rainy season. During 2023 season, the result revealed significant effect of variety ($P \leq 0.05$) at 3WAS. Mai adua and royal statistically recorded the highest number of leaves better than banana. At 6WAS and 9WAS no effect of variety was recorded. These results can be attributed to smaller size nature of banana leaves most especially during the advanced stage of growth. There was no effects of intra row spacing across all sampling periods. The result further revealed no interaction effect between variety and intra row spacing across all sampling regime at 2023.

The result further revealed that, during 2024 season there was significant ($P \leq 0.05$) difference among the varieties at 3WAS in terms of number of leaf which ranged from 13.09 to 20.77 with banana recorded the highest followed by other varieties. However, no effect of variety was observed on number of leaves at 6WAS and 9WAS. The result further showed that there was no significant effect of intra row spacing across all the sampling periods. These results was confirmed by Yacob *et al* (2015) who reported that intra row spacing had no significant effect on number of leaf. The result also disagreed with the findings of Andargachew *et al* (2020) who reported that number of leaves of green beans was significantly influenced by plant population and intra row spacing. The result further revealed lack of interaction between variety and intra row spacing across all sampling period of 2024. The varieties were not significantly difference in respect to number of leaf except at early growing stage after emergence to few weeks. These can also be connected to germination and emergence ability of the genotype.



Table 2: Influence of Variety and Intra Row Spacing on Number of Leaf of Green Bean during Rainy Season at Bauchi State

Treatments	Weeks after Sowing (WAS) 2023			2024		
	3	6	9	3	6	9
Variety						
Banana	21.72 ^a	54.6	92.7	20.77 ^a	51.6	91.6
Maiaduwa	16.35 ^b	44.5	72.5	15.51 ^b	40.5	71.6
Royal	14.01 ^c	52.2	94.5	13.09 ^c	50.2	92.6
LS	**	NS	NS	**	NS	NS
SE±	1.078	8.68	17.17	1.051	8.36	17.03
Intra row spacing (cm)						
30	16.98	58.1	80.1	16.05	54.1	78.1
40	18.91	49.3	90.2	17.83	46.2	89.2
50	16.19	43.9	89.3	15.48	41.9	88.5
LS	NS	NS	NS	NS	NS	NS
SE±	1.078	8.68	17.17	1.51	8.36	17.03
Interaction						
VxS	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) in a row are statistically similar by DMRT, LS level of significance, SE+ standard error , ** significant at 0.01 probability level , NS not significant

Leaf Area

Table 3: presented the result on the influence of variety and intra row spacing on leaf area of green bean at different growth stages during 2023 and 2024 raining season. In 2023 season, the result revealed significant ($P \leq 0.05$) difference among the varieties throughout the sampling periods. The result further showed that at 3WAS, maiaduwa and royal recorded statistically the same leaf area ahead of banana ranged from 4.5cm² to 30.8cm². At 6WAS however, maiaduwa and royal also recorded statistically the overall leaf area better than banana. At 9WAS royal and maiaduwa obtained the highest leaf area compared to banana. These result can be attributed to the smaller nature of banana leaves when compared to other two varieties which have bigger leaf. The table further revealed the effect on intra row spacing where there was no significant effects throughout the period sampled. Which is contrary to the findings of Gemechu and Solomon, (2021) who reported significant difference of leaf area on intra row spacing of green bean. Also no interaction effect of variety and intra row spacing across all period recorded during 2023.

During 2024 season, the result showed a significant effect of variety across all the sampling periods. The result revealed the leaf area ranged between 3.5cm² to 91.6cm². At 3WAS maiaduwa and royal statistically recorded the highest leaf area while banana recorded the least. At 6WAS and 9WAS maiaduwa and royal also recorded the overall leaf area better than banana. The result further revealed that, there was no effect of intra row spacing on leaf area across all the period recorded. However the result shows no interaction between variety and intra row spacing throughout the sampling period under review during 2024 season. The significantly larger leaf area of maiaduwa and royal compared to banana could be attributed to the wider leaves and climbing nature of former two varieties which gave them ability to intercept solar radiation there by causing their leaves to expand. Large leaf area obtained from maiaduwa and royal over banana could be attributed to the inherent characteristics of the varieties, this confirmed that genetic variation existed between the varieties (Mondal *et al.*, 2012)



Table 3: Influence of Variety and Intra Row Spacing on Leaf Area (cm²) of Green Bean during Rainy Season in Bauchi State

Treatments	Weeks after sowing (WAS)					
	2023			2024		
	3	6	9	3	6	9
Variety						
Banana	4.5 ^b	13.0 ^b	7.0 ^b	3.5 ^b	12.1 ^b	6.2 ^b
Maiaduwa	30.8 ^a	71.5 ^a	74.5 ^a	29.9 ^a	67.5 ^a	73.4 ^b
Royal	28.8 ^a	56.0 ^a	92.4 ^a	27.7 ^a	52.0 ^a	91.6 ^a
LS	**	**	**	**	**	**
SE±	2.77	9.33	20.90	2.70	9.22	20.87
Intra row spacing (cm)						
30	18.9	50.3	74.4	17.9	47.4	73.3
40	24.1	42.3	44.1	23.1	39.3	43.2
50	21.1	47.9	55.5	20.0	44.9	54.7
LS	NS	NS	NS	NS	NS	NS
SE±	2.77	9.33	20.90	2.70	9.22	20.87
Interaction						
VxS	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) in a row are statistically similar by DMRT, LS level of significance, SE± standard error, ** significant at 0.01 probability level, NS not significant

Number of Branches

Table 4: presented the result on the influence of variety and intra row spacing of number of branches of green bean at different growth stages at Bauchi during 2023 and 2024 rainy season. The result revealed the significant ($P \leq 0.05$) difference among the varieties at 9WAS. Royal recorded the overall number of branches (36.6) followed closely by maiadua (29.5) while banana recorded the fewest number of branches. The research result agreed with the findings of Andargachew *et al* (2015) who reported number of branches per plant was highly significantly influenced by variety and plant population. The result further shows that there was no significant effect of intra row spacing across all the sampling period of 2023 season. However no interaction effect was observed between variety and intra row spacing throughout the period.

In 2024 season however, the result revealed the statistical difference among the varieties as 9WAS. Royal recorded the highest number of branches followed by maiaduwa while banana recorded the least among the varieties. There was significant ($P \leq 0.05$) difference among the intra row spacing at 3WAS during 2024 season. 50cm and 40cm recorded statistically the same number of branches while 30cm recorded the least number of branches these might be due to the limited competition among the plants. This agreed with Yacob *et al* (2015) findings who reported that number of branch significantly influenced by intra row spacing. However no effect of intra row spacing on number of branches was obtained in later and advanced stage of the plant growth. The result further revealed no interaction between variety and intra row spacing across all sampling period of 2024.

The differences observed between the years of trial on number of branch could be attributed to the genotype variation and how they respond and utilize intra row spacing. The result further revealed that, 40cm and 50cm recorded the highest number of branches due to the fact that they took advantage of wider intra row spacing to intercept solar radiation there by improving all the growth parameters.

However, the difference on the number of branches expressed at the later stage of crop cycle, can be attributed to variance in the variety owing to their shot life cycle, where major differences in these can be expressed and seen at on advanced stage of the plant development. The result was in conformity with the findings of Almaz (2019) who reported that highest number of branches per plant was obtained at the smallest plant population and wider intra row spacing. In addition Alemayehu *et al*, (2015) also reported that higher number of branches with smallest number of plant per population.



Table 4: Influence of Variety and Intra Row Spacing on Number of Branch of Green Bean during Rainy Season in Bauchi State.

Treatments	Weeks after sowing (WAS) 2023			2024		
	3	6	9	3	6	9
Variety						
Banana	4.82	13.1	22.0 ^b	3.87	12.0	19.7 ^b
Maiaduwa	5.15	18.2	29.5 ^{ab}	4.09	17.2	28.6 ^{ab}
Royal	4.84	18.4	36.6 ^a	3.91	17.4	35.8 ^a
LS	NS	NS	*	NS	NS	*
SE±	0.45	3.33	4.91	0.42	3.33	5.36
Intra row spacing (cm)						
30	4.32	16.5	32.4	3.28 ^b	15.5	29.0
40	5.30	16.5	26.5	4.34 ^a	15.5	26.8
50	5.18	16.7	29.2	4.26 ^a	15.7	28.3
LS	NS	NS	NS	*	NS	NS
SE±	0.446	3.33	4.91	0.422	3.33	5.36
Interaction						
VxS	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) in a row are statistically similar by DMRT, LS level of significance, SE± standard error, * significant at 0.05 probability level, NS not significant

Yield and Yield Components of Green Beans

Table 5: presented the results on the influence of variety and intra row spacing on days to 50% flowering, 100 seed weight and number of pod per plant of green bean in Bauchi state during 2023 and 2024 rainy season. The result revealed significant ($P \leq 0.05$) difference across all varieties in terms of days to 50% flowering. Maiaduwa the fewest days to fifty percent flowering (46.00) followed by royal (53) while banana (59) recorded the highest days leading to 50% flowering. At 100 seed weight, there was significant ($P \leq 0.05$) difference among the varieties across all the years of trial with banana recorded the highest 100 seed weight ranged from 20.48 to 21.48. Maiaduwa and royal recorded statistically the same 100 seed weight in both trials. The weightiest 100 seed weight recorded by banana can be related to the big size of the variety compared to other two varieties. The result further revealed significant effect of variety on number of pods across all the years of trail. Royal and maiaduwa was statistically similar in terms of number of pod per plant against banana which recorded the least (7.2). In conformity with the result, Kenneth (2012) reported significant effect of variety on the number of pod per plant of green bean.

However, the result further shows the significant ($P \leq 0.05$) difference on the effect of intra row spacing of green bean on days to 50% flowering and number of pod per plant across 2023 and 2024 season. 30cm outperformed other treatments on days to 50% flowering in both trials while 40cm and 50cm are statistically similar at both year of the research. 30cm further shows significant effect on the number of pods per plant which is statistically the same with 40cm during 2023 trial. Gemechu and Solomon (2021) disagreed with result reported not significant effects of intra row spacing on days to 50% flowering of green bean. Birhanu *et al.*, (2015) had reported similar result as well.

In 2024, 30cm outperformed other intra row spacing on number of pod per plant (24.0) while 40cm and 50cm are statistically similar with 19.9 and 12.7 respectively. Contrary to the findings of the research, Gemechu and Solomon (2021) reported that number of pod per plant increased with decreasing plant density or increasing intra row spacing. The result further revealed the significant interaction between all the treatments on days to 50% flowering during 2023. In 2024 there was interaction effect between variety and intra row spacing on days to 50% flowering and number of pod per plant. Maiaduwa and royal production of more number of pods compared to banana. These corroborates with the finding of Dauda *et al* (2015) who reported early flowering varieties had more number of pods. Similar result was reported by Anjani *et al* (2009) utilization of growth factors (water, sunlight and soil nutrients) can translate into yield components such as number of pods.



Table 5 : Influence of Variety and Intra Row Spacing on Days to 50% Flowering, 100 Seed Weight(kg) and Number of Pod per Plant of Green Bean during Rainy Season in Bauchi State

Yield parameters						
Treatments	2023			2024		
	D50%F	100SW	NPP	D50%F	100SW	NPP
Variety						
Banana	59.22 ^a	21.48 ^a	7.5 ^b	59.22 ^a	20.48 ^a	7.2 ^b
Maiaduwa	46.00 ^c	16.83 ^b	25.3 ^a	46.00 ^c	15.83 ^b	24.3 ^a
Royal	53.33 ^b	18.15 ^b	26.0 ^a	53.33 ^b	17.27 ^b	25.0 ^a
LS	**	**	**	**	**	**
SE±	0.16	1.07	3.27	0.16	1.06	3.26
Intra row spacing (cm)						
30	54.11 ^a	18.85	24.8 ^a	54.11 ^a	17.85	24.0 ^a
40	52.22 ^b	18.27	20.7 ^a	52.22 ^b	17.38	19.9 ^b
50	52.22 ^b	19.35	13.4 ^b	52.22 ^b	18.35	12.7 ^c
LS	**	NS	**	**	NS	**
SE±	0.163	1.074	3.27	0.163	1.057	3.26
Interaction						
VxS	**	NS	NS	**	NS	**

Means followed by same letter(s) in a column are statistically similar by DMRT, LS level of significance, SE± standard error, ** significant at 0.01 probability level, NS not significant, D50%F days to fifty percent flowering, 100SW one hundred seed weight, NPP number of pod per plant.

Table 6: presented the result on the influence of variety and intra row spacing on the number of seeds per pod, pod weight per plot, seed yield per plot and total yield per hectare of green bean in Bauchi state during 2023 and 2024 cropping season. The result revealed significant ($P \leq 0.05$) difference among the variety on number of seed per plant, seed yield per plot and total yield per hectare throughout the periods of the research. The effect of variety on number of seed per plant shows maiaduwa and royal significantly produced the overall number of seed per plant that is statistically at par with banana variety at both trials. The differences recorded on number of seed per plant can be attributed to differences on number of pods where maiaduwa and royal consistently recorded the highest number of seed yield. Gatechwe *et al* (2014) however reported the contrary. The result on pod weight per plot shows that all varieties were significantly at par with one another in both cropping season. In another findings by Dauda *et al*, (2015) reported variety of green beans were statistically similar and significantly had more pod weight per plot during 2009,2010 and 2011 cropping season. The effect of variety on seed yield per plot shows that maiaduwa and royal variety significantly ($P \leq 0.05$) produced the highest seeds per plot and the least was recorded by banana during 2024 season. The disparity observed on seeds yield per plot could be connected to differences on number of pods where maiaduwa and royal consistently obtained the highest number of pod per plant compared to banana. The tables further revealed the result obtained on the effect of variety on the total yield per hectare which shows significant ($P \leq 0.05$) difference on total yield per hectare (t/ha) during both cropping season. Royal significantly produced the highest total yield (7.41t/ha) that is statistically at par with maiaduwa variety (6.34t/ha) and the lowest total yield was recorded by banana (2.0t/ha). The result agreed with findings of Bala *et al* (2023) who reported significant effect of green bean varieties on the total yield per hectare. The result further in agreement with another findings by Bala *et al* (2022) who reported variation in total and marketable pod yield of green bean among varieties. Bala *et al* (2022) further reported that total yield disparity is attributed to superiority of one variety over others as some varieties are generally high yielding than the other variety. Similar findings were reported by (Richardson et al., 2012; pegu and khalita, 2020)

Ratnasari *et al*, (2015) stated that each cultivar has different genetic characteristics which leads to differences in appearance, character, as well as response to production factors where different varieties of green bean tested showed variation in their yielding capacity. Similarly, disparity and increase in the yield of green bean can be attributed to the genetic potential, greater use of production



inputs, better agronomic practices and more favorable growing environment the combination of all these factors which provide maximum yield per unit of crop land (Abdel-mawgoud *et al.*, 2005).

At different intra row spacing across two season of research, there was no differences on the three intra row spacing. They are all statistically the same across the yield components tested. The result is against the findings of Gemechu and Solomon (2021) who reported highly significant ($P < 0.01$) effect of intra row spacing of green bean. The result is also in contrary to another findings by Gemechu and Solomon (2021) who reported grain yield per unit area increased with closer intra row spacing which might be due to higher plant population but yield of individual plants decreased probably due to intense inter plant competition for resources such as nutrients, water, solar radiation as manifested by high plant mortality, high level of pod abortion and low number of pods per plant at the highest density plant. In agreement with this reported that, increasing plant population reducing yield of individual plants but increase yield per unit area of green bean (Nleya *et al.*, 2001) Similarly reported the high population ensured early canopy coverage and maximized light interception (Muasya *et al.*, 2002). On another different finding by Gemechu and Solomon (2021) reported that the highest harvest index or total yield value was recorded at wider intra row spacing of 15cm. The result however agreed with the findings of Yacob *et al.*, (2015) who reported that Grain yield tends to increase with increasing intra row spacing up to 10cm beyond which it was significantly decreased. The highest grain yield (9.058t/ha) was observed from the narrower intra row spacing of 10cm which was statistically at par with the total yield of 5cm. Mitiku (2017) reported that in case of too wide intra row spacing, yield reduction can occur due to the inefficient utilization of the growth factors.

Table 6: Influence of Variety and Intra Row Spacing on Number of Seed per Plant, Pod Weight per Plot, Seed Yield per Plot and Total Pod Yield per Hectare of Green Bean during Rainy Season in Bauchi State

Yield parameters								
Treatments	2023				2024			
	NSPP	PWPP	SYPP	TY/ha	NSPP	PWPP	SYPP	TY/ha
Variety								
Banana	16.8 ^b	4.2	69 ^b	2.43 ^b	15.9 ^b	4.1	65.6 ^b	2.01 ^b
Maiaduwa	52.7 ^a	7.5	248 ^a	6.34 ^a	51.7 ^a	6.8	215.1 ^a	5.54 ^a
Royal	70.6 ^a	6.0	330 ^a	7.41 ^a	69.5 ^a	5.5	306.9 ^a	6.56 ^a
LS	**	NS	**	**	**	NS	**	**
SE±	11.33	3.07	57.1	0.232	11.33	2.91	55.3	0.284
Intra row spacing (cm)								
30	47.4	5.8	212	4.21	46.3	5.3	64	3.54
40	58.1	4.2	274	5.29	57.1	3.8	76	3.14
50	34.7	7.8	161	2.85	33.9	7.2	57	2.25
LS	NS	NS	NS	NS	NS	NS	NS	NS
SE±	11.33	3.07	57.1	0.232	10.23	2.91	55.3	0.284
Interaction VxS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) in a column are statistically similar by DMRT, LS level of significance, SE± standard error, ** significant at 0.01 probability level, NS not significant, NSPP number of seed per plant, PWPP pod weight per plot, SYPP seed yield per plot, TPY/ha total pod yield per hectare.

CONCLUSIONS AND RECOMMENDATION

Based on the result of these findings, both growth, phenology, yield and yield components of green bean were influenced by different varieties and intra-row spacing. It can be concluded from the result obtained that, Maiaduwa and royal had a better performance showed significant effect on both growth and yield parameters. Similarly, intra row spacing of 30cm and 40cm increased growth and yield of green bean in the study area. Further research should be conducted to ascertain and authenticate the result obtained across the seasons and location in the study area since a significant effect was observed on some parameters of green bean.



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