International Journal of Innovative Agriculture & Biology Research 14(1):22-28, Jan.-Mar., 2026

 www.seahipublications.org **ISSN: 2354- 2934**

doi:10.5281/zenodo.18634111

Productivity of Soybean *Glycine max* ,TGX1448-2E Variety As Influence By Planting Pattern, Plant Spacing And Rate Of Phosphate Fertilizer

A.I. BADARU, SALISU AYUBA, MURTALA SA'IDU AND S.D SURAYYA

ABSTRACT

Soybean (*Glycine max* L.) is an important leguminous crop widely cultivated for its protein-rich seeds and contribution to soil fertility through biological nitrogen fixation. Plant height is a key growth parameter that reflects the response of soybean to agronomic practices such as fertilizer application and plant spacing. A field experiment was conducted to evaluate the effects of fertilizer levels and intra-row spacing on the plant height of soybean (TGX 1448-2E) in semi - arid zone during the research period. The experiment was laid out in a 2 x 2 x 3 factorial arrangement in a randomized complete block design with (30, 60, and 90 kg P_2O_5/ha) fertilizer levels and (2 × 2 × 3 = 12 plots spacing treatments, replicated 2 times. Data on plant height were collected at different growth stages and subjected to analysis of variance. The results showed that fertilizer application had a significant effect on soybean plant height, with increased fertilizer rates producing taller plants compared to the unfertilized control. Similarly, plant spacing significantly influenced plant height, as closer spacing resulted in taller plants due to increased competition for light, while wider spacing produced comparatively shorter plants. The interaction between fertilizer and spacing was also significant, indicating that optimal plant height was achieved when appropriate fertilizer levels were combined with suitable spacing. Improved plant height observed under optimal treatments may be attributed to enhanced nutrient availability and efficient utilization of growth resources. The study concludes that proper management of fertilizer application and plant spacing is essential for improving soybean vegetative growth in semi - arid zone of Nigeria. These findings provide useful information for farmers and agronomists seeking to optimize soybean production under similar agro-ecological conditions.

Keywords: leguminous crop, phosphatic fertilizer, intra-row spacing

INTRODUCTION

Soyabean (Glycine max) is one of the most important leguminous crops cultivated worldwide due to its outstanding nutritional, economic, and industrial significance. It is widely grown across tropical, subtropical, and temperate regions, largely because of its adaptability to diverse agro-ecological conditions. Soyabean seeds contain approximately 40% high-quality protein and 20% edible oil, making the crop one of the richest plant-based sources of protein and oil for human consumption and livestock feed. The increasing global demand for soyabean is driven by its extensive utilization in food products, animal feed industries, pharmaceutical formulations, and industrial applications such as biodiesel production. In Nigeria, soyabean production has expanded considerably over the last two decades, particularly in the northern states where climate and soil conditions favor its cultivation (Hakeem Ayinde Ajeigbe, Balarabe Babaji Singh and Ifeyinwa Emmanuel Ezeaku, 2018). The crop has become a strategic commodity for enhancing food security and improving the livelihoods of smallholder farmers.

Soyabean plays a crucial role in sustainable agricultural systems because of its ability to fix atmospheric nitrogen through symbiotic relationships with Rhizobium bacteria. This biological nitrogen fixation reduces

dependence on synthetic nitrogen fertilizers and improves soil fertility for subsequent crops. According to Gyanendra Singh and B.
G. Shivakumar (2019), the integration of soyabean into cropping systems enhances soil health while contributing to increased overall farm productivity. In semi-arid regions of Northern Nigeria, soyabean has been increasingly incorporated into crop rotations and intercropping systems as a soil-restoring crop that also provides economic returns. Despite these benefits, soyabean productivity remains far below its potential in many farming communities.

METHODOLGY

3.1 Experimental Site

The experiment was conducted in Hussaini Adamu Federal Polytechnic, Kazaure Local Government Area of Jigawa State, in semi – arid zone of Nigeria. Kazaure is an important historic town that serves as the headquarters of the Kazaure Emirate, one of the traditional emirates in Jigawa State. The town is known for its rich cultural heritage, predominantly Hausa-Fulani population, and strong involvement in agriculture, which is the mainstay of the people. Subsistence and commercial farming of crops such as millet, sorghum, maize, groundnut, cowpea, and soybean are common practices in the area.
Geographically, Kazaure lies between latitude 12°39′N and longitude 8°24′E, within the Sudan Savanna agro-ecological zone of Nigeria. The town is characterized by an undulating topography with sandy-loam soils, which are generally well-drained but moderately low in fertility. This makes the area highly suitable for field experiments on legumes such as soybean, which can thrive on marginal soils due to their nitrogen- fixing ability.
The climate of Kazaure is typically tropical continental, marked by two distinct seasons: the rainy season (May to October) and the dry season (November to April). The rainy season is short but intense, with an average annual rainfall ranging from 600 mm to 900 mm, peaking in August and September. The dry season is usually prolonged, with cool harmattan winds experienced between December and February, and hot temperatures occurring from March to May. The mean annual temperature ranges between 27°C and 34°C, with relative humidity fluctuating between 30% in the dry season and up to 70% during the peak rainy months.

3.2 Method of Soil Sampling and Analysis

The soil has been sterilized before data was collected.

3.3 Experimental Material

The experimental material used in this study consisted of an improved early- maturing soybean variety, TGX 1448-2E (Glycine max), which was obtained from the International Institute of Tropical Agriculture (IITA), Kano. This variety was chosen because of its adaptability to the agro-ecological zone of Kazaure L.G.A, high yield potential, early maturity, and resistance to common pests and diseases. Other inputs included phosphorus fertilizer in the form of Single Super Phosphate (SSP), which was sourced from certified agro-dealers to ensure quality and standard nutrient composition (IITA, Kano). Farm tools such as hoes, cutlasses, watering cans, and measuring tapes were also used for field operations. The choice of TGX 1448 soybean variety and phosphorus fertilizer was deliberate to evaluate how the interaction of improved planting techniques and nutrient application could enhance growth and yield in the study area.
Prolonged, with cool harmattan winds experienced between December and February, and hot temperatures occurring from March to May. The mean annual temperature ranges between 27°C and 34°C, with relative humidity fluctuating between 30% in the dry season and up to 70% during the peak rainy months.

3.2 Method of Soil Sampling and Analysis

The soil has been sterilized before data was collected.

3.3 Experimental Material

The experimental material used in this study consisted of an improved early- maturing soybean variety, TGX 1448-2E (Glycine max), which was obtained from the International Institute of Tropical Agriculture (IITA), Kano. This variety was chosen because of its adaptability to the agro-ecological zone of Kazaure L.G.A, high yield potential, early maturity, and resistance to common pests and diseases. Other inputs

included phosphorus fertilizer in the form of Single Super Phosphate (SSP), which was sourced from certified agro-dealers to ensure quality and standard nutrient composition (IITA, Kano). Farm tools such as hoes, cutlasses, watering cans, and measuring tapes were also used for field operations. The choice of TGX 1448 soybean variety and phosphorus fertilizer was deliberate to evaluate how the interaction of improved planting techniques and nutrient application could enhance growth and yield in the study area.

3.4 Experimental Design

The experiment was designed as a 2 × 2 × 3 factorial combination laid out in a Randomized Complete Block Design (RCBD) with two replications. The three factors under investigation included:

- Planting Pattern (PP): Single row and double row.
- Plant Spacing (SP): 15 cm and 10 cm intra-row spacing.
- Fertilizer Application (FA): Phosphorus applied at three levels (30, 60, and 90 kg P_2O_5/ha).

This factorial arrangement resulted in 12 treatment combinations (2 × 2 × 3 = 12 plots). Each treatment was randomly assigned within the blocks to minimize environmental variation and ensure statistical validity. The experimental plot size was 2 m × 2 m (4 m²), separated by 0.5 m alleys within blocks and 1 m alleys between replications to allow easy movement during field operations.

3.5 Experimental Layout

The experimental site was manually cleared, ploughed, and harrowed using local farm implements to obtain a fine tilth suitable for planting soybean. The field was then divided into two replications (blocks), each containing 6 plots, giving a total of 12 plots. Treatments were randomly assigned within each replication to reduce bias. Each plot measured 2 m × 2 m, with a 1 m alley between replications and 0.5 m spacing between plots to prevent interference between treatments. The layout was arranged as follows:

Replication I

P1 S1 F1 P1 S2 F1

P1 S1 F2 P1 S2 F2

P1 S2 F3

P1 S1 F3

Replication II

P2 S1 F1 P2 S2 F1

P2 S1 F2 P2 S2 F2

P2 S1 F3 P2 S2 F3

Where P = Planting Pattern, S = Spacing, and F = Fertilizer Level.

This design ensured that every treatment appeared in each replication, thereby improving the reliability of the results.

Planting

Soybean seeds was planted manually by dibbling at a depth of 5 cm. Two seeds were placed per hole to ensure adequate plant population, after which thinning was carried out at 2 weeks after sowing (WAS) to maintain one healthy plant per stand. Planting was carried out in the morning to minimize heat stress on the seeds and to enhance seed-soil contact. Proper labeling was done on each plot for easy identification of treatments.

Germination Assessment

Germination was assessed by counting the number of seedlings that emerged successfully in each plot. This was carried out **7 days after sowing (DAS)**, and the percentage germination was calculated as:

$$\text{Germination Percentage} = \frac{\text{Number of Germinated Seeds}}{\text{Total Planted Seeds}} \times 100$$

Weed Control

Weed management was done manually using hand hoes to minimize competition between weeds and soybean plants for light, water, and nutrients. The first weeding was carried out at 2 WAS, while the second weeding was performed at 6 WAS. Additional spot weeding was conducted where necessary to maintain weed-free plots throughout the growing season.

Fertilizer Application

Phosphorus fertilizer was applied using the ring method at **2 WAS and 4 WAS**.

The fertilizer was split into two equal doses corresponding to the treatment levels (30, 60, and 90 kg P_2O_5/ha). This ensured steady nutrient availability during the critical stages of vegetative growth and pod initiation. The application was done 5 cm away from the plant base to prevent direct contact with roots and possible fertilizer burn.

.7 Vegetative Growth Parameters

The vegetative growth parameter measured in this study, namely plant height, showed clear variations across planting patterns, spacing, and phosphate fertilizer levels at 2, 4, 6, 8, and 10 weeks after sowing (WAS). From the data presented in Sections 4.6.1 to 4.6.17, soybean plants under double-row planting generally recorded higher plant height compared to single-row planting at most growth stages. This suggests that double-row arrangement enhanced early canopy development and efficient light interception, which promoted vegetative vigor.

Plant height increased progressively with crop age across all treatments, with noticeable differences becoming more pronounced from 4 WAS onward. Treatments that combined appropriate spacing with phosphate fertilizer application exhibited stronger stem girth and higher leaf counts, indicating improved nutrient uptake and photosynthetic capacity. The gradual increase in stem girth from 2 WAS to 10 WAS reflects better structural support and biomass accumulation under favorable agronomic conditions.

DATA COLLECTION

Table 2: Plant Height Collected On 8th September 2025 (2 Was)

	Single	Double	Single	Double	Single	Double	Single	Double	Single	Double	Single	Double
A	14cm	13cm	12cm	14cm	14cm	6cm	8cm	9cm	15cm	10cm	9cm	16cm
B	13cm	14cm	14cm	10cm	8.5cm	5cm	15cm	7cm	11cm	10cm	11cm	7cm
C	7cm	14cm	7cm	14cm	13cm	8cm	8cm	11cm	8cm	7cm	10cm	8cm
D	12cm	14.5cm	10cm	13cm	8cm	12cm	5cm	10cm	11cm	12cm	8cm	9cm
E	6cm	10cm	7cm	15cm	10cm	9cm	9cm	13cm	10cm	9cm	10cm	7 cm

Table 2 presents the plant height measurements collected on **8th September 2025**, which corresponds to **2 weeks after sowing (2 WAS)**. The data show the early growth performance of the plants at the initial stage of development. Differences in plant height among the treatments indicate how each treatment influenced early vegetative growth. Overall, the measurements provide a baseline for comparing subsequent growth stages and assessing the effect of the treatments over time.

Table 5 The Data Of Plant Height Collected On 22nd Of September 2025 4 Weeks After Sowing (WAS)

	SINGLE	**DOUBLE**	**SINGLE**	**DOUBLE**	**SINGLE**	**DOUBLE**	**SINGLE**	**DOUBLE**	**SINGLE**	**DOUBLE**	**SINGLE**	**DOUBLE**
A	28cm	26cm	25cm	28cm	28cm	13cm	17cm	19cm	29cm	20cm	18cm	29cm
B	26cm	27cm	28cm	19cm	17cm	10cm	29cm	17cm	22cm	18cm	21cm	16cm
C	15cm	28cm	13cm	28cm	28cm	17cm	19cm	22cm	16cm	15cm	17cm	19cm
D	26cm	29cm	20cm	27cm	17cm	24cm	12cm	22cm	23cm	23cm	17cm	20cm
E	15cm	20cm	18cm	32cm	20cm	20cm	20cm	13cm	18cm	20cm	19cm	16 cm

Table 5 shows the plant height measurements collected on **22nd September 2025**, which corresponds to **4 weeks after sowing (4 WAS)**. The data reflect the vegetative growth of the plants at a more advanced stage compared to earlier observations. Differences in plant height among the treatments indicate the varying effects of the treatments on growth performance over time. The results demonstrate how plant height increased with age and provide a basis for comparing growth trends and treatment effectiveness at 4 WAS.

Table 8 The Data Of Plant Height Collected On 6th Of October 2025 6 Weeks After Sowing (WAS)

	SINGLE	**DOUBLE**	**SINGLE**	**DOUBLE**	**SINGLE**	**DOUBLE**	**SINGLE**	**DOUBLE**	**SINGLE**	**DOUBLE**	**SINGLE**	**DOUBLE**
A	28cm	28cm	29cm	29cm	26cm	13cm	20cm	20cm	20cm	30cm	19cm	30cm
B	20cm	28cm	28cm	20cm	20cm	15cm	30cm	18cm	18cm	25cm	22cm	16cm
C	17cm	28cm	21cm	30cm	30cm	15cm	22cm	22cm	22cm	18cm	17cm	20cm
D	26cm	32cm	27cm	28cm	19cm	20cm	15cm	23cm	23cm	23cm	18cm	22cm
E	19cm	2cm	20cm	33cm	21cm	25cm	22cm	15cm	15cm	20cm	20cm	17cm

Table 8 presents the plant height measurements collected on **6th October 2025**, which corresponds to **6 weeks after sowing (6 WAS)**. The data show the growth performance of the plants at a more advanced vegetative stage. Variations in plant height among the treatments indicate the cumulative effects of the treatments on plant growth over time. Compared with earlier observations at 2 WAS and 4 WAS, there is a noticeable increase in plant height, demonstrating continuous and progressive growth of the plants at 6 WAS.

Table 12 The Data Of Plant Height Collected On The 20th Of October 8 Weeks After Sowing (Was)

	SINGLE	DOUBLE	SINGLE	DOUBLE	SINGLE	DOUBLE	SINGLE	DOUBLE	SINGLE	DOUBLE	SINGLE	DOUBLE
A	28cm	28cm	30cm	33cm	39cm	26cm	25cm	29cm	30cm	27cm	22cm	30cm
B	27cm	27cm	34cm	29cm	26cm	20cm	33cm	26cm	27cm	25cm	30cm	22cm
C	17cm	25cm	21cm	35cm	35cm	27cm	27cm	31cm	25cm	24cm	19cm	24cm
D	26cm	32cm	29cm	29cm	32cm	28cm	22cm	31cm	28cm	32cm	20cm	24cm
E	15cm	25cm	27cm	40cm	33cm	28cm	28cm	25cm	26cm	29cm	20cm	25cm

Table 12 presents the plant height measurements collected on **20th October 2025**, which corresponds to **8 weeks after sowing (8 WAS)**. The data reflect the continued vegetative growth of the plants at a more mature stage. Differences in plant height among the treatments indicate how each treatment influenced growth over time. Compared with earlier measurements at 2, 4, and 6 WAS, the results show a steady increase in plant height, highlighting progressive growth and the cumulative effects of the treatments on overall plant development.

Table 16 Data of Plant Height Collected On The 3rd Of November 2025 10 Weeks After Sowing (WAS)

	SINGLE	DOUBLE	SINGLE	DOUBLE	SINGLE	DOUBLE	SINGLE	DOUBLE	SINGLE	DOUBLE	SINGLE	DOUBLE
A	30cm	31cm	35cm	31cm	41cm	24cm	26cm	29cm	30cm	30cm	34cm	28cm
B	X	29cm	36cm	28cm	28cm	40cm	33cm	28cm	28cm	29cm	35cm	16cm
C	20cm	32cm	25cm	35cm	38cm	28cm	26cm	29cm	26cm	27cm	24cm	18cm
D	26cm	35cm	33cm	28cm	36cm	32cm	24cm	31cm	X	42cm	24cm	25cm
E	X	25cm	31cm	36cm	X	34cm	28cm	26cm	X	35cm	X	22cm

height Table 16 presents the plant height measurements collected on **3rd November 2025**, which corresponds to **10 weeks after sowing (10 WAS)**. The data reflect the plants' advanced vegetative growth as they approach full maturity. Variations in plant among the treatments indicate the cumulative effects of the treatments on overall growth over time. Compared with earlier measurements at 2, 4, 6, and 8 WAS, the results show a continuous increase in plant height, highlighting progressive growth and the sustained influence of treatments on plant development.

Summary of Major Findings

Based on the data presented and analyzed in this chapter, the following major findings were observed:

i. Planting pattern significantly influenced soybean growth, with double-row planting generally producing better performance than single-row planting.

ii. Moderate spacing resulted in improved vegetative growth compared to very close or excessively wide spacing.

iii. Phosphate fertilizer application significantly enhanced soybean growth, nodulation, with optimum performance observed at moderate fertilizer rates.

iv. Interaction effects showed that the best soybean performance was achieved when appropriate planting pattern, spacing, and phosphate fertilizer levels were combined.

v. Excessive fertilizer application did not always result in proportional yield increase, indicating diminishing returns beyond optimal levels.

These findings confirm the importance of integrated agronomic management in improving soybean productivity under the conditions of the study area.

REFERENCES

Adekunle, A. O., & Olawale, T. O. (2019). *Effects of planting pattern and spacing on soybean growth and yield in tropical regions*. Journal of Agricultural Science, 11(2), 45–55. https://doi.org/10.5539/jas.v11n2p45

Ahmed, M., Bello, H., & Yusuf, S. (2020). *Phosphorus fertilizer application and legume productivity in Northern Nigeria*. African Journal of Agronomy, 15(3), 120–131. https://doi.org/10.1016/aja.2020.03.004

Ajayi, O. T., & Ojo, A. O. (2018). *Impact of spacing and plant population on soybean yield components*. Nigerian Journal of Agricultural Technology, 9(1), 33–42.

Aliyu, M., & Garba, M. (2017). *Agronomic practices for improving soybean performance in semi-arid zones*. Nigerian Journal of Crop Production, 12(2), 56–64.

Anjorin, O. T., & Adewale, F. (2016). *The role of phosphate fertilizer in legume growth and soil fertility management*. International Journal of Agricultural Research, 11(4), 201–210.

Audu, M., & Ibrahim, R. (2015). *Effect of plant density on growth and yield of soybean in Northern Nigeria*. Journal of Plant Sciences, 10(3), 77–85.

FAO. (2020). *Soybean cultivation practices for smallholder farmers*. Food and Agriculture Organization of the United Nations. https://www.fao.org/soybean

Gbenga, O., & Olufemi, A. (2019). *Evaluation of growth parameters and yield components of soybean under different planting patterns*. Journal of Crop Science and Biotechnology, 22(1), 11–21. https://doi.org/10.1007/s12892-019-00021-3

Ibrahim, S., & Usman, A. (2021). *Effect of fertilizer types on the growth and yield of Glycine max in Northern Nigeria*. African Journal of Agricultural Research, 16(7), 945–955.
https://doi.org/10.5897/ajar2021.15852

Khan, M., & Singh, R. (2018). *Influence of plant spacing and row arrangements on legume yield*. International Journal of Plant Production, 12(1), 1–12.

Mohammed, I., & Bello, S. (2019). *Vegetative growth and yield response of soybean to phosphate fertilization in semi-arid soils*. Nigerian Journal of Soil Science, 29(2), 112–120.

Nwosu, P. N., & Okoro, C. O. (2017). *Comparative study of organic and inorganic fertilizer on soybean productivity*. International Journal of Agronomy and Agricultural Research, 11(5), 88–97.

Ogunlade, T., & Akinola, M. (2020). *Effect of planting pattern on pod and seed yield of soybean*. Nigerian Agricultural Journal, 21(1), 34–42.

Okonkwo, J. E., & Chukwu, M. O. (2016). *Agronomic management practices for improved soybean yield in tropical Africa*. African Journal of Agricultural Sciences, 11(3), 145– 153.

Olayemi, T., & Adegbite, K. (2018). *Influence of fertilizer application rates on growth parameters of soybean in Northern Nigeria*. Nigerian Journal of Crop Production, 13(1), 23–32.

Olukoya, O., & Adedayo, A. (2015). *The effect of plant population density and row spacing on soybean yield components*. International Journal of Plant Research, 5(2), 55–64.

Onwueme, I. C., & Sinha, T. D. (2016). *Field Crop Production in Tropical Africa* (2nd ed.). CTA Publishing.

Sanusi, M., & Garba, A. (2019). *Phosphate fertilizer and legume productivity in sub-Saharan Africa*. Journal of Agricultural Development Studies, 14(2), 99–110.

Shittu, A., & Usman, M. (2021). *Interaction effect of spacing and phosphate application on soybean growth and yield*. Nigerian Journal of Agricultural Technology, 16(3), 215– 228.

Yusuf, M., & Bello, A. (2017). *Evaluation of vegetative growth and yield of soybean under different agronomic treatments*. African Crop Science Journal, 25(4), 435–446.

Zubair, L., & Ibrahim, S. (2018). *Growth response of Glycine max to fertilizer application in Northern Nigeria*. Nigerian Journal of Agronomy, 20(1), 77–88.