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EFFECTS OF VARIETIES AND PLANT SPACING ON THE GROWTH AND YIELD OF SOYBEAN (*Glycine max* (L) Merrill.) IN GOMBE, SUDAN SAVANNA

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Abstract: Field experiment was conducted during the 2023 rainy season at Teaching and Research Farm of Faculty of Agriculture, Federal University of Kashere (Latitude 90 54' 46''N, Longitude 110 0' 27''E at 431 m above the sea level) Akko Local Government Area, Gombe State and at the Teaching and Research Farm of the Federal College of Horticulture Dadinkowa, Yamaltu-Deba Local Government Area, Gombe State. The treatments consisted of a factorial combination of three varieties of soybean (TGX-20D, TGX-1951 and TGX1448-2E) and three plant spacing of (20, 30 and 40 cm). These were laid out in a Randomized Complete Block Design (RCBD) with three replications. The results of the study showed that soybean variety TGX1448-2E significantly produced higher of (9.35 t/ha) yield than TGX-20D (9.04 t/ha) and TGX-1951 (9.03 t/ha). The 40 cm plant spacing, significantly enhanced yield of (9,868.332 kg) than 20 (8,415.833kg) and 30 cm plant spacing (9,133.333 kg). Therefore, TGX1448-2E and 40 cm plant spacing should be used by farmers who grow soybean based from their superior performances by producing higher growth and yield of soybean.

Keywords: *Varieties, Spacing, Growth, Yield and Soybean.*

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Introduction

Soybean (*Glycine max* (L.) Merrill) is a legume crop, the origin of soybean is still not clear but many botanists believe that it was first domesticated in central China as early as 7,000 BC (Andrade *et al.*, 2002). Cultivar selection is an important management practice to maximize yield. An environment free of stress allows each cultivar to attain its maximum genetic yield potential (Awasarmal *et al.*, 2014). However, plant growth and yield are reduced by abiotic and biotic stresses occurring in the environment (Cox and Cherney, 2011). Daniel *et al.* (2011) found different responses of cultivars based on environment, as a result, cultivar selection, which must be made based on genotypic interactions with the environment to maximize yield. Soybean growth in a wider row spacing make them always to get 95% light interception, which is required for maximum dry matter accumulation (Conley *et al.*, 2008). Dry matter accumulation decreased as the width of rows increased (Board, 2010). A higher crop growth rate was observed to be crucial to soybean yield formation in the comparison of narrow and wider rows (Ball *et al.*, 2000; Board, 2010). This coincides with the conclusion that the time of greatest yield benefits to narrow rows occurred before the main grain fill period (Aniekwe and Mbah, 2014).

Great variations exist in the study of row spacing; wider rows have a yield advantage over narrow rows (Ball *et al.*, 2000; Board *et al*, 2011). Narrow rows produced greater yields, but no correlation was observed between plant population and yield (Dapaah *et al.*, 2005). Higher plant populations, however, were found to increase lodging, seed weight and leaf area index, but decreased the number of branches/plant (Cox and Cherney, 2011). Another study observed that increased in plant population in narrow rows increased yield by 27%, while not affecting lodging and harvest index (Caliskan *et al.*, 2007).

Soybean planted in lower populations was observed to produce more lateral branches ((Ball *et al.*, 2000; Board *et al.*, 2010). As a result of greater lateral branching, soybean plants in lower populations were found to fill the inter-row spaces at lower leaf area index than higher populations (Dereje, 2014). The period of vegetative growth is lengthened in greater plant populations, leading to a competition for carbohydrates of vegetative growth and grain fill (Bowers *et al.*, 2000). As a result of this competition, less carbohydrate is often available for seed fill, decreasing yield in high populations (Bowers *et al.*, 2000). While increased in plant populations appeared to increase yield (De-Bruin and Pedersen, 2008c).

Many studies have also found an optimum plant population, beyond which yield will not increase (De Bruin and Pedersen, 2008c). The range of plant population density to maximize yield is found of 104 500 grains per hectare (Agdew *et al.*, 2012) and 680 000 plants per hectare (De-Bruin and Pedersen, 2009). Though an optimum plant population density of 462 000 plants per hectare was observed, 95% of the maximum soybean yield could be attained with a final harvest population of 258 600 plants per hectare (De-Bruin and Pedersen, 2008c). Soybean in narrow rows leads to quicker canopy closure which may result in greater light interception (Andrade *et al.*, 2002). In narrow rows, soybean plants are at more equidistant, resulting into early season canopy cover as compared with plants in wider row spacing (De-Bruin and Pedersen, 2008b). Narrow row spacing has been found to increase yields under favorable weather conditions (De-Bruin and Pedersen, 2008a; Cox and Cherney, 2011). However, narrow row spacing can reduce yields under adverse weather conditions

(Daroish *et al.*, 2005).

Soybean is a legume crop with higher oil and protein content; it can supply most of its nitrogen requirements and provides residual nitrogen for subsequent crop when its tissues decompose. Although soybean production has gained popularity, its overall yield remains low and production is below consumer demand. This low yield has been attributed to several factors among which are; improper choice of variety and plant spacing. It is expected that at the end of this research work, the results obtained will provide our farmers with a high yielding variety and proper plant spacing that will enhance the productivity of soybean in the study areas. In view of the above, the study was designed to determine the effect of variety and plant spacing on the growth and yield of soybean in the study areas.

Materials and Methods

Experimental Sites

Field experiment was conducted during the 2023 rainy season, at the Teaching and Research Farm of the Faculty of Agriculture, Federal University of Kashere (Latitude 9^{0}54N, Longitude 11^{0} 27'E) and altitude 349 m above the sea level) and the Teaching and Research Farm of Federal College of Horticulture Dadin-Kowa (Latitude 10^{0} 18'E and Longitude 11^{0}30 N and altitude of 218m above sea level).

Treatments and Experimental Design

The experiment consisted of three varieties of soybean **(**TGX-20D, TGX1951 and TGX1448-2E) and three plant spacing (20, 30 and 40 cm). These were combined and laid out in a randomized complete block design (RCBD) with three replications.

Cultural Practices

The land was cleared manually using a hand hoe and rake. The layout was designed and pegged after which beds was raised using a hand hoe. Three seeds of soybean were sown per hole and later thinned to two seedlings/stand after emergence, weeding was done manually where applicable using a hoe. Gross plot size was 3 x 2 m and net plot size was 2 x 1 m. Pathways were created of plots and replications at 50 cm and 1 m, respectively (Black, 1965).

Data Collection

Plant height (cm)

Plant height was measured from the base of the plant to the terminal bud of the main stem from the five sampled plants using a measuring tape graduated in cm; the average was taken and recorded.

Number of leaves/plant

Total number of leaves/plant from the five sampled plants was obtained by physical counting; the average was taken and recorded.

Number of branches/plant

Number of branches/plant was obtained by physical counting of number branches from the five sampled plants; the average was taken and recorded.

Number of nodules/plant

Number of nodules/plant was obtained by physical counting of number of nodules from the five sampled plants; the average was taken and recorded.

Leaf area (cm^2)

Leaf area was measured manually from the five sampled plants and the average was taken and recorded. Measurements were done by determining the leaf length and breadth and would be multiplied by a factor of (0.80) (Akanbi *et al.*, 2010).

Days to 50 % flowering

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

Number of pods/plant

Number of pods/plant was obtained by physical counting the cobs from the five sampled plants in each treatment; the average was taken and recorded.

Number of pods/ha

Number of pods/ha was obtained by converting number of pods/plant to per hectare using the net plot size (2 m^2).

100 Seed weight (g)

100 seeds were weighed from the five sampled plants in each treatment, the average taken and recorded.

Shelling (%)

Shelling % was determined by dividing seed yield with pod yield and then multiplied by 100% from the five sampled plants in each treatment; the average was taken and recorded.

Pod yield/plant (g)

Pod yield/plant was obtained by weighing the grains from the five sampled plants in each treatment; the average was taken and recorded.

Pod yield/ha (kg)

Pod yield/ha was obtained by converting grain yield/plant to grain yield/ha.

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).

Results

Plant height (cm)

Table 1 shows the effect of variety and plant spacing on plant height of soybean at Kashere, Dadinkowa and the Mean. There was a significant difference ($\rho \leq 0.05$) among the treatment means due to variety on plant height. TGX-20D significantly produced a higher mean value of (47.15, 46.57 and 46.86), which was followed by TGX1448-2E which produced mean values of (46.85, 46.53 and 46.69), followed by TGX-1951 which produced the lowest mean of (46.67, 46.09 and 46.38) on plant height of soybean at Kashere, Dadinkowa and the mean. There was a significant difference ($\rho \leq 0.05$) among the treatment means due to plant spacing. Plant spacing of 20 cm significantly produced the highest means of (50.20, 47.86 and 49.03), followed by plant spacing of 30 cm which produced mean values of (46.72, 46.87 and 46.79), followed by plant spacing of 40 cm which produced the lowest mean values of (43.74, 44.46 and 44.10) on plant height of soybean. There was no significant interaction at ($\rho \leq 0.05$) of variety with plant spacing on plant height of soybean at Kashere, but no significant interaction ($\rho \geq 0.05$) at Dadinkowa and the mean.

Number of leaves/plant

Table 1 shows the effect of variety and plant spacing on the number of leaves/plant across the two locations. There was a significant difference (P≤0.05) among the treatment means due to variety on the number of leaves/plant. TGX-20D significantly produced the highest mean values of (16.56, 15.95 and 16.26), followed by TGX-1951 which produced mean values of (16.27, 15.43 and 15.85) and TGX1448-2E which produced the lowest number of leaves/plant of (15.70, 15.93 and 15.82) on soybean. Table 1 also shows the effect of plant spacing on the number of leaves/plant of soybean at Kashere, Dadikowa and the Mean. There was a significant difference (P≤0.05) among the treatment means due to plant spacing. Plant spacing of 20 cm significantly produced the highest means of (19.28, 17.29 and 18.28), followed by plant spacing of 30 cm which produced mean values of (15.62, 16.15 and 15.88), followed by plant spacing of 40 cm which produced the lowest mean values of (13.64, 13.88 and 13.76) on number of leaves/plant of soybean. There was no significant interaction at (P≥0.05) of variety with plant spacing on number of leaves/plant of soybean at Kashere, Dadinkowa and the mean.

Number of branches/plant

Table 2 shows the effect of variety on number of branches/plant of soybean at Kashere, Dadikowa and the Mean. There was a significant difference (P≤0.05) among the treatment means due to variety on the number of branches/plant. TGX-20D significantly produced the highest mean values of (7.83, 7.43 and 7.46), followed by TGX1951 which produced mean values of (7.41, 7.43 and 7.42), followed by TGX1448-2E which produced the lowest mean values of (6.99, 6.98 and 6.99) on number of branches/plant of soybean at Kashere, Dadinkowa and the mean. Table 2 also shows the effect of plant spacing on the number of branches/plant of soybean at Kashere, Dadikowa and the combined. 20 cm plant spacing significantly produced the highest means of (8.43, 8.20 and 8.32), followed by 30 cm plant spacing which produced means of (7.28, 7.33 and 7.31), followed by 40 cm plant spacing which produced means of (6.17, 6.31 and 6.24) There was no significant interaction at (P≥0.05) of variety with plant spacing on the number of branches/plant at Kashere, Dadinkowa and the combined. However, significant interaction (P≤0.05) was observed of variety with plant spacing at Kashere on the number of branches/plant.

Leaf area (cm2)

Table 2 shows the effect of variety on leaf area of soybean at Kashere, Dadikowa and the Mean. There was a significant difference (P≤0.05) among the treatment means due to variety on leaf area. TGX1448-2E significantly produced the highest mean values of (48.87, 48.77 and 48.82), followed by TGX-1951, which produced mean values of (48.54, 48.21 and 48.37), followed by TGX-20D which produced the lowest means of (47.56, 47.24 and 47.40) on leaf area of soybean at Kashere, Dadinkowa and the mean.

Table 2 shows the effect of plant spacing on leaf area of soybean at Kashere, Dadikowa and the Mean. There was a significant difference (P≤0.05) among the treatment means due to plant spacing on leaf area. The 40 cm of plant spacing significantly produced the highest mean values of (548.36, 52.09 and 50.23), followed by 30 cm, which produced mean values of (48.29, 47.95 and 48.12), followed by 20 cm which produced the lowest means of (52.31, 44.17 and 44.27) on leaf area of soybean at Kashere, Dadinkowa and the mean. There was no significant interaction at (P≥0.05) of variety with plant spacing on leaf area at Kashere, Dadinkowa and the mean.

Number of nodules/plant

Table 3 shows the effect of variety on number of nodules/plant of soybean at Kashere, Dadikowa and the Mean. There was no significant difference (P≥0.05) among the treatment means due to variety on number of nodules/plant. Table 3 shows the effect of plant spacing on the number of nodules/plant of soybean at Kashere, Dadikowa and combined. There was a significant difference (P<0.05) among the treatment means due to plant spacing. The 20 cm plant spacing significantly produced higher means on number of nodules/plant of (6.96, 5.41 and 5.62, followed by 30 cm plant spacing which produced means of (6.27, 6.08 and 6.18), followed by 40 cm plant spacing which produced means of (5.84, 6.97 and 6.96 There was also no significant interaction at (P≥0.05) of variety with plant spacing on number of nodules/plant at Kashere, Dadinkowa and the mean.

Days to 50% flowering

Table 3 shows the effect of variety on days to 50% flowering of soybean at Kashrere, Dadikowa and the Mean. There was a significant difference (P≤0.05) among the treatment means due to variety on days to 50% flowering at Dadinkowa and combined, but no significant difference at Kashere. TGX-1951 significantly the highest means of (45.73and 45.96), followed by TGX-20D which produced means of (45.38 and 45.63), followed by TGX1448-2E which produced the lowest means of (44.65 and 44.86) on days to 50% flowering. Table 3 shows the effect of plant spacing on days to 50% flowering of soybean at Kashere, Dadikowa and combined. There was a significant difference (P≤0.05) among the treatment means due to plant spacing.

The 20 cm of plant spacing significantly produced the highest means of (48.15, 46.85 and 47.50), followed by 30 cm of plant spacing which produced means of (45.32, 44.99 and 45.15), followed by 40 cm of plant spacing which produced the lowest means of (43.66, 43.93 and 43.80) on days to 50% flowering. There was no significant interaction at (P≥0.05) of variety with plant spacing on days to 50% flowering at Kashere, Dadinkowa and combined.

Number of pods/plant

Table 4 shows the effect of variety on number of pods/plant of soybean at Kashere, Dadikowa and combined. There was no significant difference (P≥0.05) among the treatment means due to variety on number of pods/plant. Table 4 also shows the effect of plant spacing on number of pods/plant of soybean at Kashere, Dadikowa and combined. There was a significant difference (P≤0.05) among the treatment means due to plant spacing. The 20 cm of plant spacing significantly produced the highest means on number of pods/plant of (22.95, 22.46 and 22.71), followed by 30 cm of plant spacing which produced means of (20.55, 19.29 and 19.92), followed by 40 cm of plant spacing which produced the lowest means of (18.60, 17.83 and 18.22) on number of pods/plant. There was no significant interaction at (P≥0.05) of variety with plant spacing on the number of pods/plant at Kashere, Dadinkowa and combined.

Number of pods/ha

Table 4 shows the effect of variety on number of pods/ha of soybean at Kashere, Dadikowa and combined. There was no significant difference (P≥0.05) among the treatment means due to variety on number of pods per hectare at Kashere, Dadinkowa and combined. Table 4 shows the effect of plant spacing on the number of pods per hectare of soybean at Kashere, Dadikowa and combined. The 20 cm of plant spacing significantly produced the highest number of pods per hectare of (8912.49, 8871.66 and 8892.49), followed by 30 cm of plant spacing which produced means of (9712.49, 9607.49 and 9659.99), followed by 40 cm of plant spacing which produced means of (11549.99, 11518.33 and 11529.33). There was no significant interaction at (P≥0.05) of variety with plant spacing on number of pods per hectare at Kashere, Dadinkowa and combined.

100 seed weight (g)

Table 5 shows the effect of variety on 100 seed weight of soybean at Kashere, Dadikowa and combined. There was no significant difference (P≥0.05) among the treatment means due to variety on 100 seed weight at Kashere, Dadinkowa and combined. Table 5 shows the effect of plant spacing on 100 seed weight of soybean at Kashere, Dadikowa and combined. There was a significant difference among the means due to plant spacing on 100 seed weight. The 20 plant spacing produced significantly higher 100 seed weight of (118.51, 102.89 and 102.87), followed by 30 cm plant spacing which produced means of (110.93, 109.05 and 109.99), followed by 40 plants spacing which produced means of (102.84, 117.06 and 117.79). There was no significant interaction at (P≥0.05) of variety with plant spacing on 100 seed weight at Kashere, Dadinkowa and combined.

Shelling percent (%)

Table 5 shows the effect of variety on shelling percent of soybean at Kashere, Dadikowa and combined. There was no significant difference (P≥0.05) among the treatment means due to variety on shelling percent at Kashere and Dadinkowa. Table 5 also shows that there was no significant difference among the means due to plant spacing. There was also no significant interaction effect of variety with plant spacing on shelling percent at Kashere, Dadinkowa and combined.

Pod yield/plant (g)

Table 6 shows the effect of variety on seed yield/plant of soybean at Kashere, Dadikowa and combined. There was a significant difference (P≤0.05) among the treatment means due to variety on pod yield/plant at Kashere, Dadinkowa and combined. TGX1448-2E significantly gave higher treatment means of (112.69, 111. 74 and 112.22), followed by TGX -20D which gave means of (107.72, 109.15 and 108.44) and TGX-1951 which gave the lowest treatment means of (109.21, 107.51 and 108.36). Table 6 shows the effect of plant spacing on pod yield/plant of soybean at Kashere, Dadikowa and combined. There was a significant difference (P≤0.05) among the treatment means due to plant spacing. The 20 cm of plant spacing significantly produced the highest means of (119.67, 102.15 and 100.99), followed by 30 cm of plant spacing which produced means of (110.12, 109.08 and 109.60), followed by 40 cm of plant spacing which produced the lowest means of (99.84, 117.17 and 118.42) on pod yield/plant. There was no significant interaction at (P≥0.05) of variety with plant spacing on pod yield/plant.

Pod yield/ha (kg)

Table 6 shows the effect of variety on seed yield/plant of soybean at Kashere, Dadikowa and combined. There was a significant difference (P≤0.05) among the treatment means due to variety on pod yield/ha at Kashere, Dadinkowa and combined. TGX1448-2E significantly gave higher treatment means of (9390.83, 9311.66 and 9351.66), followed by TGX -20D which gave means of (8976.66, 9095.83 and 9036.66) and TGX-1951 which gave the lowest treatment means of (9100.83, 8959.16 and 9029.99). Table 6 shows the effect of plant spacing on seed yield/plant of soybean at Kashere, Dadikowa and combined. There was a significant difference (P≤0.05) among the treatment means due to plant spacing. The 20 cm of plant spacing significantly produced the highest means of (9972.49, 8512.49 and 8415.83), followed by 30 cm of plant spacing which produced means of (9176.66, 9089.99 and 9133.33), followed by 40 cm of plant spacing which produced the lowest means of (8319.99, 9764.16 and 9868.33) on pod yield/ha. There was no significant interaction at (P≥0.05) of variety with plant spacing on pod yield/ha.

Seed yield/plant (g)

Table 7 shows the effect of variety on seed yield/plant of soybean at Kashere, Dadikowa and combined. There was a significant difference (P≤0.05) among the treatment means due to variety on seed yield/plant at Kashere, Dadinkowa and combined. TGX1448-2E significantly produced higher treatment means of (84.52, 83.81 and 84.17), followed by TGX-20D which produced treatment means of (80.79, 81.86 and 81.33) and followed by TGX-1951 which produced the lowest treatment means of (81.91, 80.63 and 81.27). Table 7 shows the effect of plant spacing on seed yield/plant of soybean at Kashere, Dadikowa and combined. There was a significant difference (P≤0.05) among the treatment means due to plant spacing. The 20 cm of plant spacing significantly produced the highest means of (89.75, 76.61 and 75.74), followed by 30 cm of plant spacing which produced means of (82.59, 81.81 and 82.20), followed by 40 cm of plant spacing which produced the lowest means of (99.84, 88.28 and 88.82) on seed yield/plant. There was no significant interaction at (P≥0.05) of variety with plant spacing on pod yield/plant.

Seed yield/ha (kg)

Table 7 shows the effect of variety on seed yield/ha of soybean at Kashere, Dadikowa and combined. TGX1448-2E significantly produced higher treatment means of (7043.12, 6983.75 and 7013.75), followed by TGX-20D which produced treatment means of (6732.50, 6821.87 and 6777.50) and followed by TGX-1951 which produced the lowest treatment means of (6825.62, 6719.37 and 6772.49). Table 7 shows the effect of plant spacing on seed yield/plant of soybean at Kashere, Dadikowa and combined. There was a significant difference (P≤0.05) among the treatment means due to plant spacing. The 20 cm of plant spacing significantly produced the highest means of (7479.37, 6384.37 and 6311.87), followed by 30 cm of plant spacing which produced means of (6882.50, 6817.49 and 6850.00), followed by 40 cm of plant spacing which produced the lowest means of (6939.99, 7323.12 and 7401.25) on seed yield/ha. There was no significant interaction at (P≥0.05) of variety with plant spacing on seed yield/ha.

Discussion

Comparing the three varieties of soybean (TGX-20D, TGX1951 and TGX1448-2E) on plant height and number of leaves/plant, it was observed that these traits were higher in TGX-20D followed by TGX1951 and TGX1448-2E. This observation may be as a result of the fact that TGX-20D being a variety that was recently released by IAR, ABU Zaria, possess the desirable qualities than TGX1951 and TGX1448-2E and was able to exhibit superior performances than TGX1951 and TGX1448-2E. This observation seems to agree with works of Lee *et al.* (2008); Worku and Astatke. (2011); Wycliffe (2015); Wondimu e*t al.* (2016); Tan *et al.* (2016) who earlier stated that newly released varieties exhibit superior performances than the late varieties in enhancing growth and yield characters.

Number of branches/plant and leaf area was significantly different among varieties, with TGX-20D producing higher treatment means than TGX1951 and TGX1448-2E. However, there was no significant difference among the varieties due to plant spacing on number of branches/plant and leaf area. There was also no significant difference among varieties and plant spacing on number of nodules/plant and days to 50% flowering. Also, there was no significant difference among varieties and plant spacing on number of pods/plant and per hectare. This observation may be that since these factors did not differ significantly on number of nodules/plant, days to 50% flowering, number of pods/plant and pods/ha. This observation corroborates the findings of Aniekwe and Mbah (2014); Sjamsijah *et al.* (2016); Maham (2011); Wodimu *et al.* (2016) who earlier reported that number of nodules/plant, days to 50% flowering do not always differ significantly especially under good environmental conditions. Among the three-plant spacing tried (20, 30 and 40 cm in this study, it was observed that varieties TGX-20D, TGX-1951 and TGX1448-2E responded differently. Results obtained showed that plants were under plant spacing of 40 cm; yield higher than plant spacing of 20 and 30 cm, respectively. This is because; wider spacing promoted the production of more yield and yield components of soybean. This means that, the wider the spacing, the more the yield and the lesser the number of days to 50% flowering. This seems to agree with works of (Rahman *et al.*, 2010; 2011; Dereje, 2014) who studied the response of soybean to different plant spacing and recorded more yield and delay in days to flowering from the wider plant spacing than the closer plant spacing.

The 40 cm of plant spacing seemed to have enhanced vegetative and reproductive performances than 20 and 30 cm of plant spacing, because plants that were spaced 40 cm, grew shorter but increase in size, accumulated more dry matter per plant, higher number of nodules/plant, higher leaf area and a greater number of pods/plant. Plant spacing as shown by researchers is one of the most important agronomic practices that is very essential for soybean growth and yield. This observation was reported by Madanzi *et al.* (2012) who observed that plant spacing usually determines plant population in a given area, which consequently resulted in yield and yield attributes. Number of pods/plant, 100 seed weight, seed yield/plant and seed yield/ha were significantly higher under 40 cm plant spacing than 20 and 30 cm plant spacing, respectively. Mahama (2011) observed that plant population of 333,333 plants/ha (75 x 20 cm) produced the highest plant height, followed by 266,666 plants/ha (75 x 30 cm) and 444,444 plants/ha (75 x 40 cm), respectively.

Mahama (2011) also observed an increase in plant height when soybean plants were spaced at 60 x 5 cm than when spaced at 50 x 5 cm, 40 x 5 cm and 30 x 5 cm, respectively. Caliskan *et al.* (2007) also stated that, within certain limits, increase in plant population density results in a reduction in growth and yield/plant, but the reverse occurs for yield per unit area. Caliskan *et al.* (2007) also observed an increase followed by a decrease in plant height with increasing plant population density in sunflower plants. Spacing 75 x 40 cm made plants to have an effective utilization of available environmental resources like light, water and nutrients, as a result of less intra plant competition, this has accounted for a greater plant height. Dereje (2014) reported significant increases in plant height in wider row spacing of 70 cm as against narrow row spacing of 40 cm, resulting in higher yield of soybean.

Conclusion

From the results of this study, soybean variety TGX1448-2E significantly produced higher yield of (9,351.66 kg) than TGX-20D (9,036.66 kg) and TGX-1951 (9,029.99 kg). The 40 cm plant spacing, significantly enhanced yield of (9868.33 kg) than 20 cm (8415.83 kg) and 30 cm, plant spacing (9,133.33 kg). TGX1448-2E and 40 cm plant spacing should be adopted by farmers who grow soybean based from their superior performances in enhancing higher growth and yield of the crop.

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Table 1: Effect of Variety and Plant Spacing on Plant Height (cm) and Number of Leaves/Plant of Soybean (*G. max* L.) at Kashere, Dadinkowa and Combined

Treatments	Plant Height (cm)			Number of Leaves/plant		
	Kashere	Dadinkowa	Com	Kashere	Dadinkowa	Com
Variety (V)						
TGX-20D	47.15	46.57	46.86	16.56	15.95	16.26
TGX1448-2E	46.85	46.53	46.69	15.70	15.93	15.82
TGX-1951	46.67	46.09	46.38	16.27	15.43	15.85
LS	0.579	0.719	0.495	0.195	0.466	0.468
LSD	NS	NS	NS	NS	NS	NS
Plant Spacing (cm)						
20	50.20	47.86	49.03	19.28	17.29	18.28
30	46.72	46.87	46.79	15.62	16.15	15.88
40	43.74	44.46	44.10	13.64	13.88	13.76
LS	0.001	0.002	0.001	0.001	0.001	0.001
LSD	0.967	1.367	0.824	0.975	0.994	0.796
Interaction						

LS	0.345	0.854	0.148	0.341	0.735	0.591
V x P	NS	NS	NS	NS	NS	NS

Con = Combined, LS = Level of Significance at 5% Level of Probability, LSD = Least Significant Difference at 5% Level of Probability, NS = Not Significantly Different at 5% Level of Probability.

Table 2: Effect of Variety and Plant Spacing on Number of Branches/plant and Leaf Area (cm2) of Soybean (*G. max* L.) at Kashere, Dadinkowa and Combined

Treatments	Number of Branches/Plant			Leaf Area (cm^2)		
	Kashere	Dadinkowa	Com	Kashere	Dadinkowa	Com
Variety (V)						
TGX-20D	7.83	7.43	7.46	47.56	47.24	47.40
TGX1448-2E	6.99	6.98	6.99	48.87	48.77	48.82
TGX-1951	7.41	7.43	7.42	48.54	48.21	48.37
LS	0.125	0.328	0.076	0.050	0.094	0.005
LSD	NS	NS	NS	1.151	1.402	0.829
Plant Spacing (cm)						
20	8.43	8.20	8.32	52.31	44.17	44.27
30	7.28	7.33	7.31	48.29	47.95	48.12
40	6.17	6.31	6.24	49.48	52.09	50.28
LS	0.001	0.002	0.001	0.001	0.001	0.001
LSD	0.616	0.709	0.448	1.072	1.402	0.829
Interaction	NS	NS	NS	NS	NS	NS
LS	0.418	0.553	0.267	0.316	0.946	0.443
V x P						

Con = Combined, LS = Level of Significance at 5% Level of Probability, LSD = Least Significant Difference at 5% Level of Probability, NS = Not Significantly Different at 5% Level of Probability.

Table 3: Effect of Variety and Plant Spacing on Number of Nodules/plant and Days to 50% Flowering of Soybean (*G. max* L) at Kashere, Dadinkowa and Combined

Treatments	Number of Nodules/Plant			Days to 50% Flowering		
	Kashere	Dadinkowa	Com	Kashere	Dadinkowa	Com
Variety (V)						
TGX-20D	6.35	6.19	6.27	45.88	45.38	45.63
TGX1448-2E	6.49	6.34	6.39	45.06	44.65	44.86
TGX-1951	6.26	5.93	6.10	46.19	45.73	45.96
LS	0.816	0.497	0.408	0.221	0.060	0.018
LSD	NS	NS	NS	NS	0.900	0.764
Plant Spacing (cm)						
20	6.96	5.41	5.62	48.15	46.85	47.50
30	6.27	6.08	6.18	45.32	44.99	45.15
40	5.84	6.97	6.96	43.66	43.93	43.80
LS	0.005	0.001	0.001	0.001	0.001	0.001
LSD	0.621	0.721	0.447	1.359	0.900	0.764
Interaction						

LS	0.453	0.769	0.276	0.173	0.181	0.185
V x P						

Con = Combined, LS = Level of Significance at 5% Level of Probability, LSD = Least Significant Difference at 5% Level of Probability, NS = Not Significantly Different at 5% Level of Probability.

Table 4: Effect of Variety and Plant Spacing on Number of Pods/plant and Number of Pod/ha of Soybean (*G. max* L.) at Kashere, Dadinkowa and Combined

Treatments	Number of Pods/Plant			Number of Pods/ha		
	Kashere	Dadinkowa	Com	Kashere	Dadinkowa	Com
Variety (V)						
TGX-20D	21.24	20.49	20.87	8, 769.99	8,707.49	8,739.16
TGX1448-2E	19.93	19.20	19.57	9,660.83	9,599.99	9,630.83
TGX-1951	20.93	19.90	20.41	10,744.16	11,658.33	11,700.83
LS	0.126	0.126	0.13	0.260	0.260	0.300
LSD	NS	NS	NS	NS	NS	NS
Plant Spacing (cm)						
20	22.95	22.46	22.71	8,912.49	8,871.66	8,892.49
30	20.55	19.29	19.92	9,712.49	9,607.49	9,659.99
40	18.60	17.83	18.22	11,549.99	11,518.33	11,529.33
LS	0.001	0.001	0.001	0.100	0.100	0.100
LSD	1.338	1.260	1.856	133.800	126.000	185.600
Interaction						
LS	0.785	0.937	0.654			
V x P	NS	NS	NS	NS	NS	NS

Con = Combined, LS = Level of Significance at 5% Level of Probability, LSD = Least Significant Difference at 5% Level of Probability, NS = Not Significantly Different at 5% Level of Probability.

Table 5: Effect of Variety and Plant Spacing on Shelling Percent (%) and 100 Seed Weight (gm) of Soybean (G. max) at Kashere, Dadinkowa and Combined

Treatments	100 Seed Weight (gm)			Shelling Percent (%)		
	Kashere	Dadinkowa	Com	Kashere	Dadinkowa	Com
Variety						
TGX-20D	109.45	109.75	109.60	11.33	11.82	11.58
TGX1448-2E	113.01	111.40	112.21	11.95	11.90	11.93
TGX-1951	109.82	10.85	108.83	11.64	11.76	11.70
LS	0.263	0.570	0.496	0.511	0.977	0.693
LSD	NS	NS	NS	NS	NS	NS
Plant Spacing (cm)						
20	118.51	102.89	102.87	11.92	11.95	11.90
30	110.93	109.05	109.99	11.84	11.98	11.95
40	102.84	117.06	117.79	11.17	11.54	11.35
LS	0.001	0.002	0.096	0.316	0.761	0.289
LSD	4.876	6.990	3.968	NS	NS	NS
Interaction						
LS	0.319	0.487	0.875	0.971	0.951	0.872
V x P	NS	NS	NS	NS	NS	NS

Con = Combined, LS = Level of Significance at 5% Level of Probability, LSD = Least Significant Difference at 5% Level of Probability, NS = Not Significantly Different at 5% Level of Probability.

Table 6: Effect of Variety and Plant Spacing on Pod yield/plant (gm) and Pod yield/ha (kg) of Soybean (G. max) at Kashere, Dadinkowa and Combined

Treatments	Pod Yield/Plant (g)			Pod Yield/ha (kg)		
	Kashere	Dadinkowa	Com	Kashere	Dadinkowa	Com
Variety (V)						
TGX-20D	107.72	109.15	108.44	8, 976.66	9, 095.83	9, 036.66
TGX1448-2E	112.69	111.74	112.22	9, 390.83	9, 311.66	9, 351.66
TGX-1951	109.21	107.51	108.36	9, 100.83	8, 959.16	9, 029.99
LS	0.062	0.067	0.065	0.130	0.134	0.132
LSD	0.445	0.438	0.443	105.006	102.004	104.005
Plant Spacing (cm)						
20	119.67	102.15	100.99	9, 972.49	8, 512.49	8, 415.83
30	110.12	109.08	109.60	9, 176.66	9, 089.99	9, 133.33
40	99.84	117.17	118.42	8, 319.99	9,764.16	9, 868.33
LS	0.001	0.013	0.001	0.010	0.010	0.010
LSD	5.755	9.385	5.152	575.500	938.500	515.200
Interaction						
LS	0.353	0.366	0.368	234.002	231.115	233.114
V x P	NS	NS	NS	NS	NS	NS

Con = Combined, LS = Level of Significance at 5% Level of Probability, LSD = Least Significant Difference at 5% Level of Probability, NS = Not Significantly Different at 5% Level of Probability.

Table 7: Effect of Variety and Plant Spacing on Seed yield/plant (g) and Seed yield/ha (kg) of Soybean (*G. max* L.*)* at Kashere, Dadinkowa and Combined

Treatments	Seed Yield/Plant (g)			Seed Yield/ha (kg)		
	Kashere	Dadinkowa	Com	Kashere	Dadinkowa	Com
Variety (V)						
TGX-20D	80.79	81.86	81.33	6732.50	6821.87	677.50
TGX1448-2E	84.52	83.81	84.17	7043.12	6983.75	7013.75
TGX-1951	81.91	80.63	81.27	6825.62	6719.37	6772.49
LS	0.052	0.056	0.054	0.125	0.126	0.126
LSD	0.241	0.238	0.239	86.002	76.010	81.006
Plant Spacing (cm)						
20	89.75	76.61	75.74	7479.37	6384.37	6311.87
30	82.59	81.81	82.20	6882.50	6817.49	6850.00
40	99.84	88.28	88.82	6939.99	7323.12	7401.25
LS	0.001	0.001	0.001	0.010	0.010	0.010
LSD	4.316	7.039	3.864	105.63	103.88	104.200
Interaction						
LS	0.715	0.725	0.720	0.750	0.752	0.751
V x P	NS	NS	NS	NS	NS	NS

Com = Combined, LS = Level of Significance at 5% Level of Probability, LSD = Least Significant Difference at 5% Level of Probability, NS = Not Significantly Different at 5% Level of Probability.