Available online at www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 127(3) (2019) 106-122 EISSN 2392-2192

Yield of cotton cultivars as influenced by nitrogen rates and plant density in Yalingo, Nigeria

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ABSTRACT

Nitrogen rates and plant density are two important practices for optimum production of cotton. Field experiment was conducted at two locations within the Research Farm, College of Agriculture, Jalingo (longitude 11° 09' and 11° 30' East and latitude 8° 17' and 9° 01' North) in Nigeria to investigate the influence of nitrogen rates and plant density on yield components of cotton cultivars. A 4 × 3 × 2 factorial of four nitrogen (N) rates (0, 120, 150, 200 kg/ha), three cotton varieties (Jalingo Local, Samcot-13, Sketch-8) and two plant densities (44,444 and 60,000 plants/ha) was arranged in a randomized complete block design (RCBD) and replicated three times. Data were collected on cotton seed yield, lint yield and number of seeds/boll. Nitrogen rate, plant density and variety had a positive effect on cotton seed yield, lint yield and number of seeds/boll. Nitrogen rates at all levels significantly ($p < 0.05$) increased the seed and lint yield of cotton when compared with control. However, the differences in yield between 150 kg N/ha and 200 kg N/ha rate was not significant making nitrogen rate of 150 kg N/ha more economical and optimum for cotton seed yield. Low plant population gave rise to higher seed yield. Interactively, the 150 kg N/ha × Jalingo Local × low plant density (44,444 plants/ha) gave the highest cotton seed and lint yield.

***Keywords*:** Cotton variety, lint yield, plant population, seed yield, urea fertilizer, nitrogen rate

(Received 27 March 2019; Accepted 12 April 2019; Date of Publication 13 April 2019)

1. INTRODUCTION

Demand for quality fiber materials is on the increase in Nigeria as the population continues to increase and clothing is among the three basic needs of man (food, shelter and clothing), therefore the demand for this multipurpose fiber crop is high. Cotton is capable of increasing the foreign exchange of Nigeria and a potential to turn her from an importing country to a net exporter. Unfortunately, total production remains far below the national requirement of the textile and the oil mills (Adeniji, 2007). Therefore, to be known as one of the world cotton producers, there is need for improvement of cotton yield through proper management of its nutrient requirements for quality yield.

The requirement ofcotton for nutrients is much higher during early growth stages, because of greater assimilatory and accumulation capacity of roots and shoots to accommodate the future needs (Ahmed *et al.*, 2016). Apart from water, nitrogen (N) is a major nutrient element limiting cotton production in most of the cotton producing regions of the world (Rochester, 2011; Devkota *et al*., 2013; Sattar *et al*., 2017).

Deficiency symptoms of N in cotton include stunting, chlorosis and fewer and smaller bolls (Sattar*et al*., 2017; Iren and Aminu, 2017a & b) while more N stimulates vegetative growth and retards flowering. However, excessive N leads to weakening of fibre and thereby affects quality. According to Rineharth *et al.* (2004) nitrogen management in cotton is particularly difficult due to problems with either excessive or inadequate rates, influence of other agronomic practices such as plant density and chemical control as well as abiotic stresses. Deficiency of cotton in nitrogen from emergence to early blooming could lead to inadequate vegetative growth, resulting in decreased fruiting (Hallikeri *et al*., 2010; Tang *et al*., 2012; Bhatiand Manpreet, 2015; Sattar *et al*., 2017). Thus, N nutrition is known to be the major pivotal facets of cotton production (Iren and Aminu, 2017a & b; Bondada and Oosterhuis, 2001)

According to Kerby*et al.* (1990), cotton cultivars developed in different ecological zones respond differently to inorganic fertilizers. Since inorganic fertilizers are too expensive to poor resource farmers, there is a need for developing cultivars that can adapt to most ecological zones being early maturing, tolerant and resistant to plant diseases. Plant population is a production factor, which affects light interception by plant canopy (Wali and Koraddi, 1989). Akhtar *et al.* (2002) reported highest yields of cotton at populations of 49,000 to 256,000 plants/ha. Darawsheh *et al.* (2009) observed that adequate population of cotton seedlings is vital to obtain high yields. Bednarz *et al.* (2000) and Rind *et al.* (2006) have observed reduced yields with extremely high or low plant population.

The cotton yield per unit area obtained by average grower in Nigeria is far less than the potential yields due to the use of poor yielding varieties, chemical fertilizers, cultural operations and poor soil fertility. Bronson concluded that cotton production was directly related to doses and application method of chemical fertilizers. Abbasi and Abro (2002) reported that application of nitrogen at all levels had positively improved cotton growth and yield. Ogunwole *et al.* (2003) found that the variation in varietal response to nitrogen nutrition was non-significant, but the effect of fertility levels was significant. Nitrogen deficiency has a profound effect on yield and quality of cotton fibres (Bondada and Oosterhuis, 2001).Thus, poor fertility status of soils is a major factor responsible for low yield of cotton in Nigeria (Iren and Aminu, 2017a & b). Therefore, this research work was carried out to investigate the influence of nitrogen rates and plant density using two improved cotton cultivars imported from China with a local one in the Nigerian savanna cotton belt in improving yield of cotton.

2. MATERIALS AND METHODS

2. 1. Study area

The field experiment was conducted at two locations within the Research Farm of the College of Agriculture, Jalingo (longitude 11° 09′and 11° 30′ E and latitude 8° 17′ and 9° 01′ N), Taraba State, Nigeria during the wet season. Jalingo lies within the northern guinea savannah region of Nigeria. The wet season usually commence in April, peak in August and ends in October while dry period begins in November and ends in March, with its peak in January and February when the dusty north-east trade winds blow across the entire area. The basement complex rock underlines the geology of Jalingo Local Government Area.

2. 2. Land preparation, experimental design and treatments

The experimental site was manually cleared, stumped, raked and burnt. The land was then tilled manually and plots measuring 2 m × 2.5 m were made. Alleyways between blocks were 2 m while those between plots were 1 m.

The experiment was laid out as a 4 × 3 × 2 factorial arrangement of treatments fitted into a randomized complete block design (RCBD) with three replicates. The treatment combinations consisted of four nitrogen rates (0,120, 150 and 200 kg/ha) in urea fertilizer with the 0 kg/ha serving as control, three cotton varieties (Jalingo Local, Samcot-13, Sketch-8) and two plant densities [low plant density (44,444 plants/ha or 75 cm by 30 cm) and high plant density (60,000 plants/ha or 60 cm by 30 cm)]. Thus, there were 24 treatment combinations, giving a total of 72 experimental plots.

2. 3. Planting and cultural practices

Seeds of the three cotton varieties (Samcot-13,Sketch-8 and Jalingo Local) were sown on a well-prepared moist seedbed at 75 cm by 30 cm for a density of 44,444 plants/ha (low density) and 60 cm by 30 cm apart for a density of 60,000 plants/ha (high density). Four seeds were sown per hole and the seedlings were thinned to one vigorous plant per stand 10 days after sowing (DAS). Nitrogen was applied as urea in two equal splits. The first application was done 21 DAS and the second at 50 DAS. Several studies (Hallikeri *et al*., 2010; Tang *et al*., 2012; Bhati and Manpreet, 2015; Sattar *et al*., 2017), have reported that nitrogen application to cotton should be completed on or before 60 days of sowing for better utilization of the applied nutrient. Weeding was done manually at 14, 50and 90 DAS.

2. 4. Data collection

Ten plants from the central rows were selected and tagged for the determination of agronomic parameters. Seed yield and lint yield per boll were obtained from the ten tagged plants after separating the lint from the cotton seed. All the seeds obtained were weighed and averaged for seed yield per boll. Two pickings from the whole plot at 130 and 150 DAS were done to obtain the seed yield and the lint yield. Seed yield per plot was determined after picking and delinting from each plot and then calculated on per hectare basis. Lint yield per plot was obtained from each plot after the seeds were separated from the lint in all the pickings and then converted to per hectare basis. Number of seeds/boll from the tagged plants per plot was counted and recorded.

2. 5. Statistical Analysis

Data collected were subjected to analysis of variance using the Stat View Software and Least Significant Difference (LSD) at the 5% level of probability was used for comparison of treatment means.

3. RESULTS AND DISCUSSION

3. 1. Yield components of cotton cultivars as influenced by nitrogen rates and plant density

3. 1. 1. Lint yield

A summary of the analysis of variance of N rates, plant density and cotton variety on yield components of cotton is shown in Table 1, while effects of various nitrogen levels, plant density and variety on lint yield per boll are shown in Figures 1 and 2. Lint yield per boll was highest at nitrogen rate of 150 kgN/ha with yield of 1.6g followed by the yield of 1.59g from 120 kgN/ha and least in control plots with yield of 1.47g (Figure 1a). Lint yields for 150 kgN/ha and 120 kgN/ha rates were not statistically different, suggesting that either of the two rates could be used for optimizing lint yield in cotton. Lint yield per boll were affected by plant density with lower density (44,444 plants/ha) producing higher lint per boll (1.59 g) compared with yield of 1.44 g obtained from high density of 60,000 plants/ha (Figure 1b). It was observed that lint yield per boll was not significantly ($p > 0.05$) affected by cotton varieties. This agrees with Ogunwole *et al.* (2003) findings who found that the variation in varietal response to nitrogen nutrition was non-significant.

Table 1. Summary of analysis of variance for yield components of cotton

Source of var.	Lint yield (g/boll)	Lint yield (kg/ha)	Seed yield (g/boll)	Seed yield (kg/ha)	Number of seeds /boll
Nitrogen Rate(N)	<.0001*	<.0001*	<.0001*	<.0001*	0.0002*
Plant density (PD)	<.0001*	<.0001*	0.9592^{NS}	<.0001*	<.0001*
Variety (V)	0.0958^{NS}	<.0001*	0.0007*	<.0001*	.0001*
N * PD	0.0128^{NS}	0.0008*	0.1132^{NS}	0.5245^{NS}	0.1100^{NS}
N * V	<.0001*	<.0001*	<.0001*	0.0086*	<.0001*
PD *V	0.0002*	0.0002*	0.1438^{NS}	0.2339^{NS}	0.0017*
N *PD* V	<.0001*	<.0001*	<.0001*	0.0212*	<.0001*

* = significant at $p<0.05$; ^{NS} = not significant

Interaction of nitrogen rate of 120 kgN/ha with lower plant density yielded more lint per boll (Figure 2a), while under plant density with variety interaction, Jalingo Local at low density recorded the highest lint yield but at high density the highest lint yield was from Samcot 13 variety (Figure 2b). Nitrogen rates interaction with variety were significant ($p < 0.05$) with rate of 150 kgN/ha combined with Jalingo Local giving highest lint yield per boll (1.69g) and the lowest yield (1.32 g) was obtained at 200 Kg N/ha rate with Jalingo Local (Figure 2c). Interactive effect of nitrogen rates, plant density and variety were significant with highest lint yield of 1.95g per boll obtained at 150 Kg N/ha with low density (44,444 plants/ha) and with Jalingo Local compared to lowest lint yield of 1.30g from interaction of 200 Kg N/ha with high density and Jalingo Local (Figure 2d). It could be inferred that optimum lint yield per boll could be achieved with the interaction of higher nitrogen doses in combination with low plant density.

A combination of either higher N rate with low density or moderate N rate with higher plant density enhances cotton yield under saline soil (Kong *et al*., 2011). Nitrogen uptake contributes to the size of cotton boll and this resulted in lint yield as the boll becomes larger at every additional dose of nitrogen applied. Plant density also affects lint yield as widely spaced plants significantly produced larger boll because of minimum competition for available nutrients, light, moisture and air which eventually lead to higher lint yield. Akhtar *et al.* (2002) reported that lower plant population of 44,444 plants/ha produced higher yield compared with higher plant population. This result is also in agreement with Bednarz *et al.* (2005) who found that cotton lint yields increased when plant density was reduced.

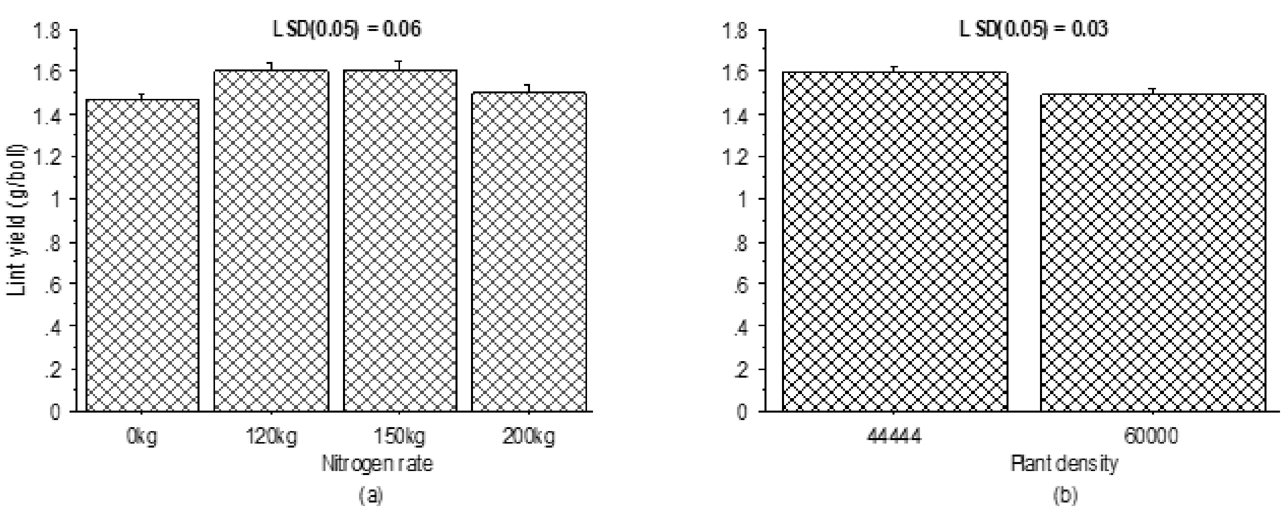


Fig. 1. Effects of (a) nitrogen rates and (b) plant density on lint yield (g/boll)

Lint yield on per hectare basis was significantly affected by various nitrogen rates, plant density, varieties and their interactions. Highest lint yield was obtained at nitrogen rate of 200 kg N/ha (525.44 kg/ha) followed by N rate of 150 kg N/ha with yield of 433.31 kg/ha compared with 135.44 kg/ha obtained from control plots (Figure 3a). Differences in lint yields between plot treated with 150 kg N/ha and 200 kg N/ha were not significant, suggesting the 150 kg N/ha as economic level for maximizing lint yield. Among the varieties, Jalingo Local yielded the highest lint of 365.71 kg/ha although not significantly higher than the yield of 363.71 kg/ha obtained from Samcot-13 (Figure 3b).

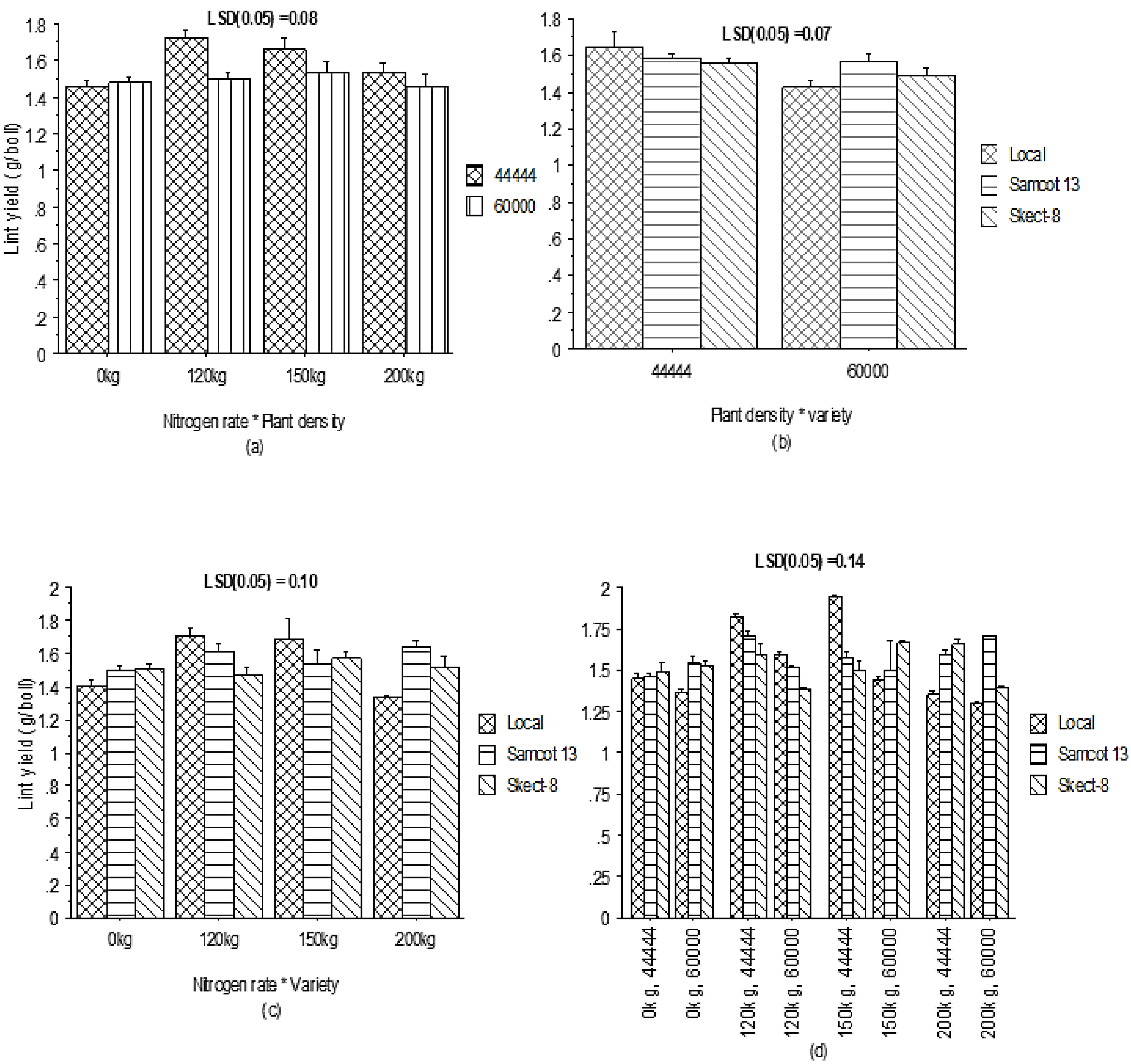


Fig. 2. Interactive effects of (a) nitrogen rates * plant density, (b) plant density * variety, (c) nitrogen x variety and (d) nitrogen * plant density * variety on lint yield (g/boll)

The effect of plant density on lint yield was highly significant, lower density (44,444 plants/ha) yielded higher lint (384.43 kg/ha) compared to 310.00 kg/ha at higher density of 60,000 plants/ha (Figure 3c). Interactive effect of nitrogen at 200 kg N/ha rate with low plant density significantly gave the highest lint yield/ha (Figure 4a). At N rate of 200 kg/ha × Samcot-13, lint yield was maximum (543.02 kg/ha) while the minimum yield (120.64 kg/ha) was obtained at 0 kg N/ha (control) with Sketch-8 (Figure 4b). Jalingo Local interacted with low plant population to significantly produced the highest lint/ha (Figure 4c).

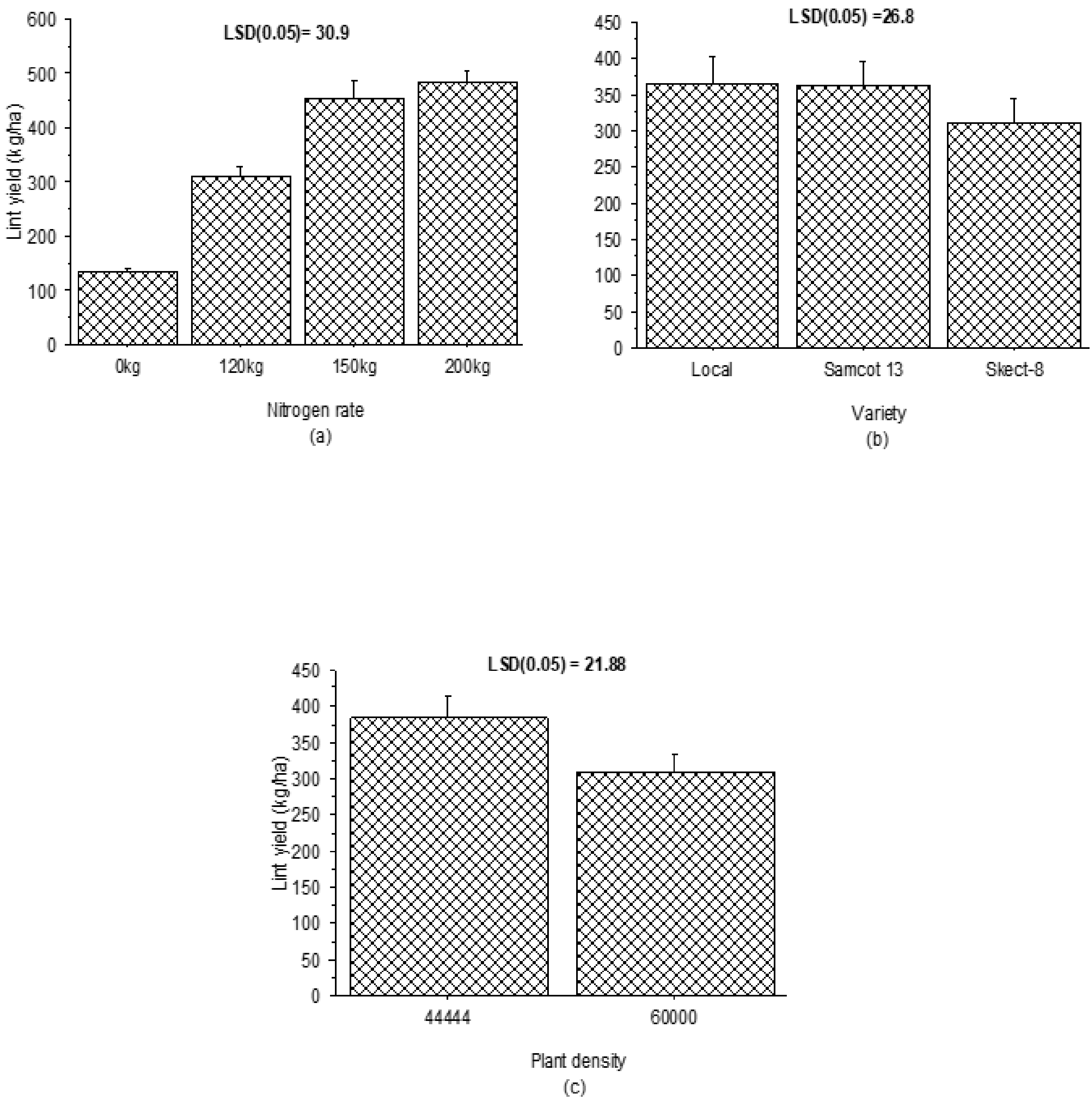


Fig. 3. Effects of (a) nitrogen rates, (b) variety and (c) plant density on lint yield (kg/ha)

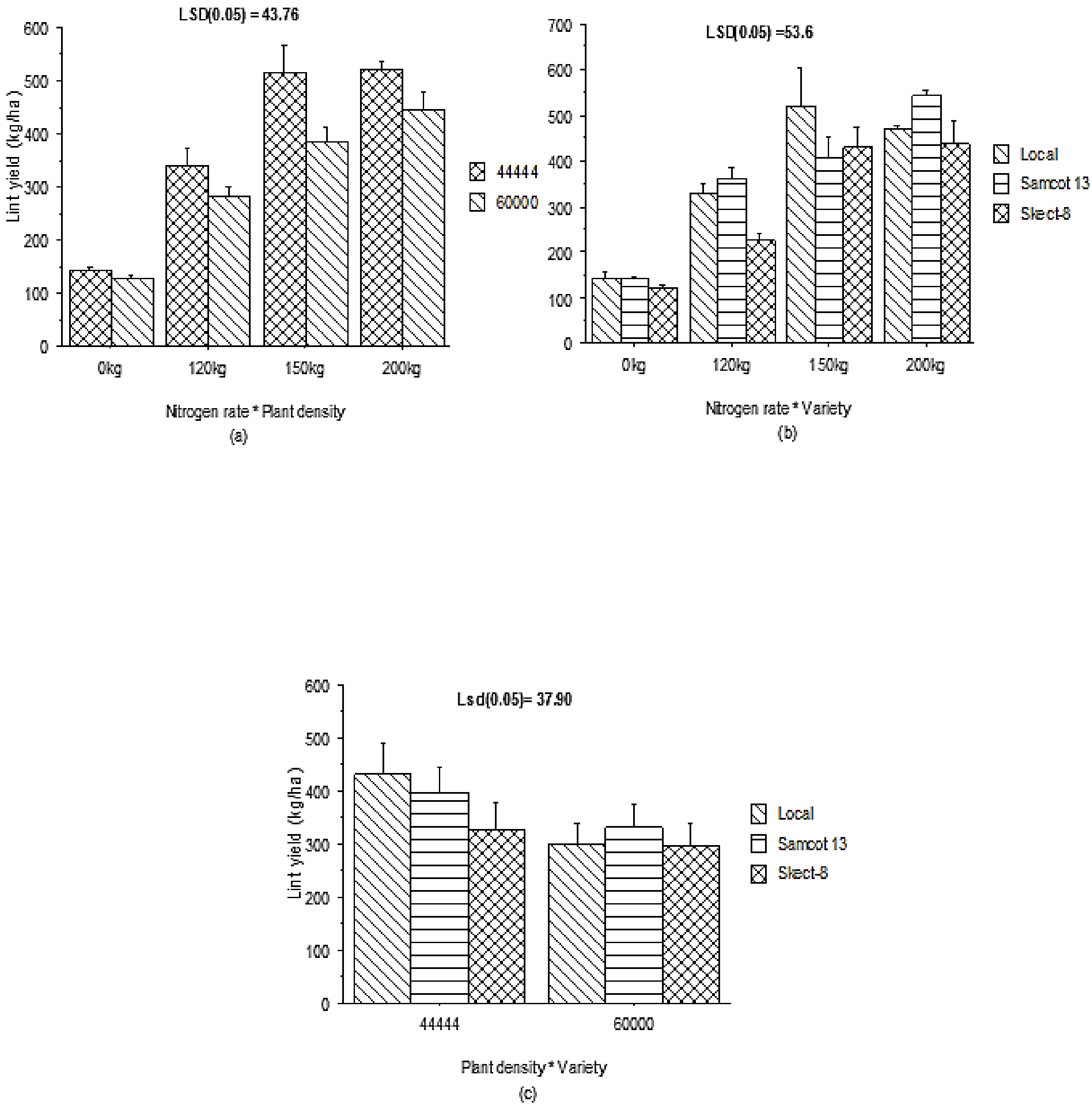
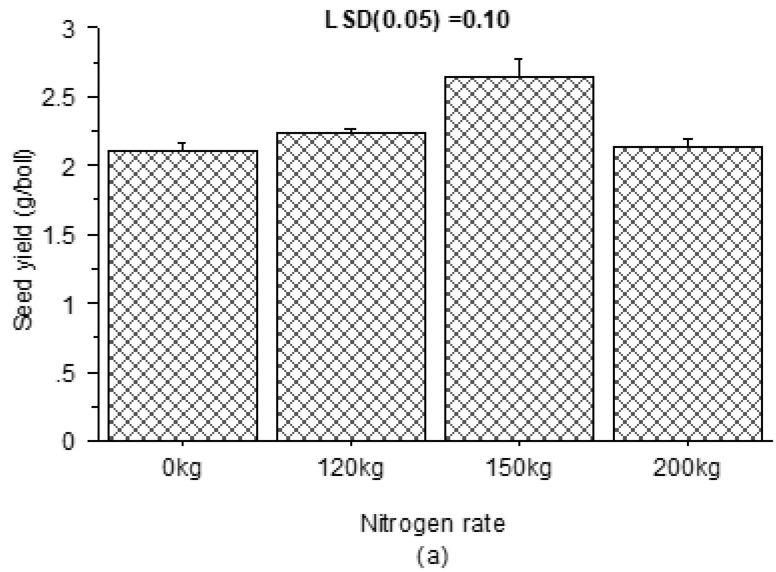


Fig. 4. Interactive effects of (a) nitrogen * plant density, (b) nitrogen * variety and (c) plant density * variety on lint yield (kg/ha)

3. 1. 2. Seed yield

Seed yield per boll at various nitrogen rates, variety and their interactions were significant (Figures 5 and 6). Nitrogen rate of 150 kg N/ha produced the largest boll of 2.64 g while the lowest yield (2.11 g) was obtained in control plots (Figure 5a). Effect of plant density on seed weight was not significant. Variety effect was significant with samcot-13 producing the highest seed yield per boll of 2.38 g (Figure 5b).



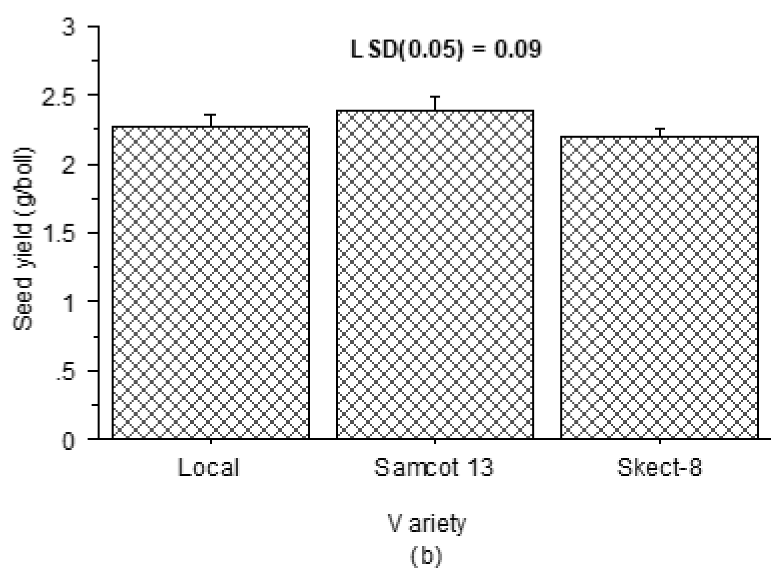


Fig. 5. Effects of (a) nitrogen rates and (b) variety on seed yield (g/boll).

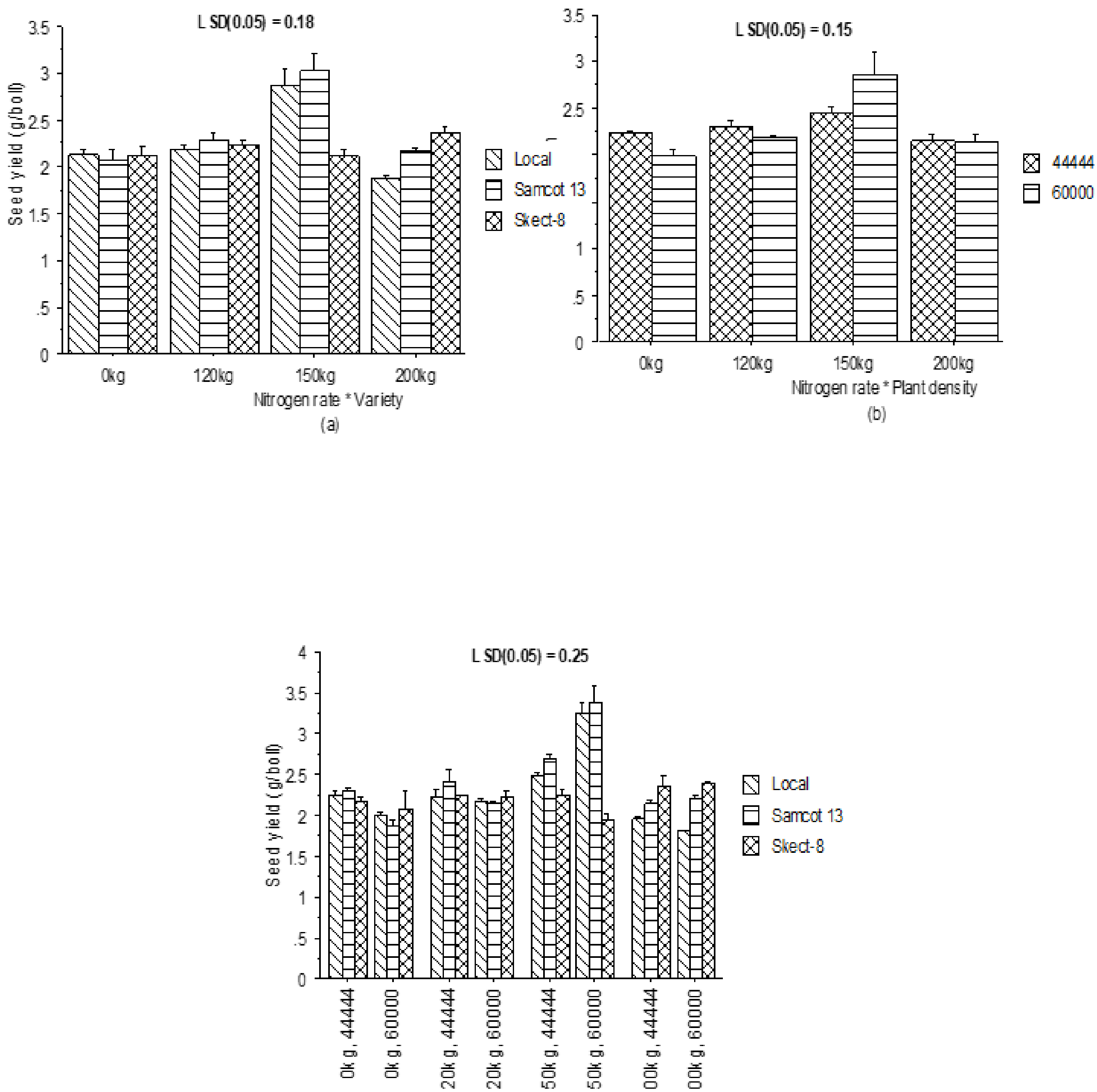


Fig. 6. Interactive effects of (a) nitrogen * variety, (b) nitrogen * plant density and (c) nitrogen * variety *plant density on seed yield (g/boll)

Interactively, seed yield per boll were significant under nitrogen rate x plant density and nitrogen rates x variety. Samcot-13 under nitrogen rate of 150 kg N/ha and nitrogen rate of 150 kg N/ha under low plant density gave the largest seed yield per boll (Figures 6a and b). While theinteraction of high density with samcot-13 at nitrogen rate of 150 kg N/ha gave the best seed yield per boll (Figure 6c). Nitrogen rate at all levels influences seed yield/boll; this is because boll size increased as the rate of application was increased which allowed for better accumulation of metabolite in the seeds hence larger seeds.

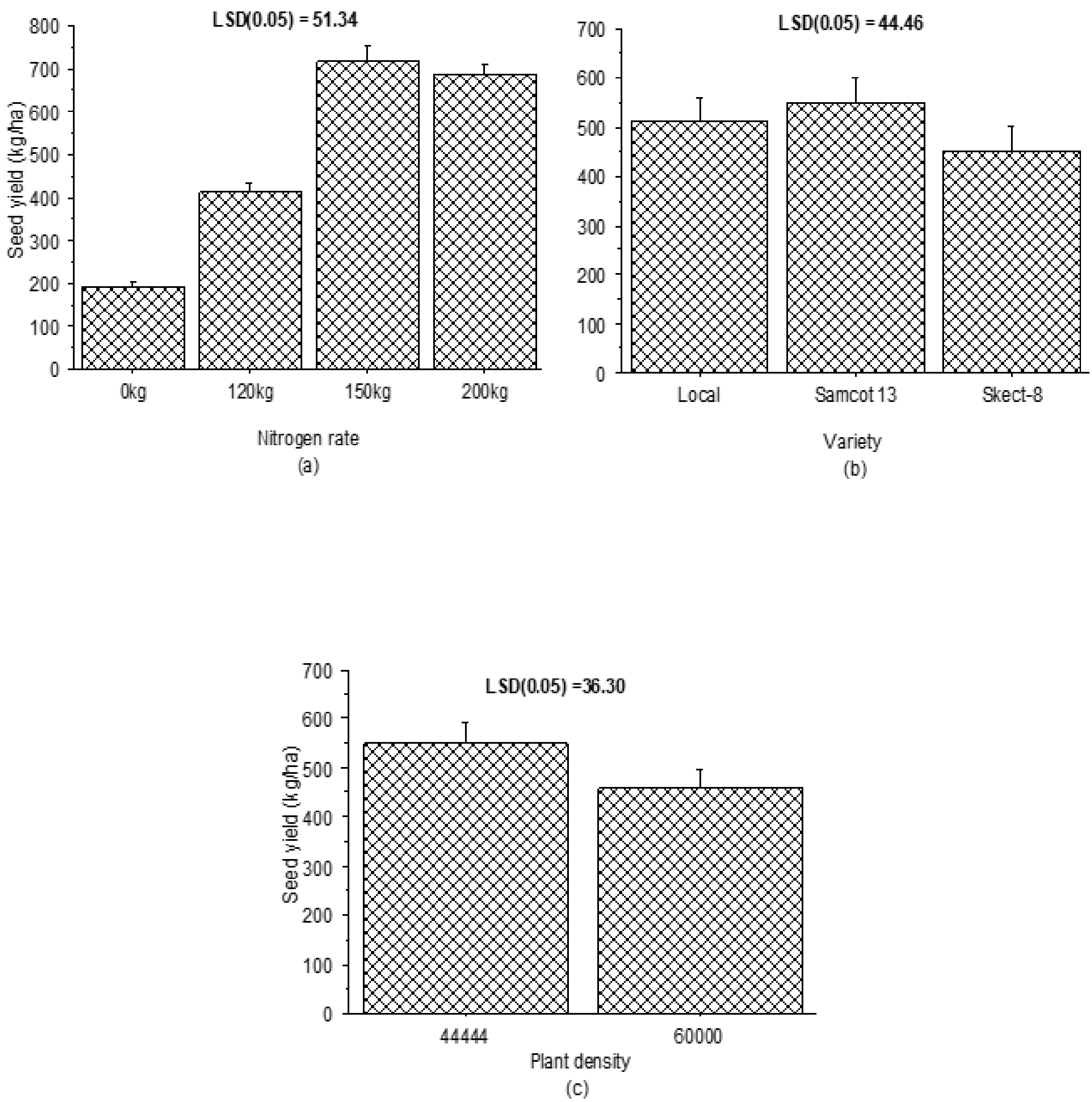


Fig. 7. Effects of (a) nitrogen rates, (b) variety and (c) plant density on seed yield (kg/ha)

The results obtained from these studies on seed yield/boll agreed with the findings of Muhammed and Javed (2006) who reported that 150 Kg N/ha rate is an economical level for obtaining maximum seed yield in cotton. Also, widely spaced plants produced bigger seeds than closely planted cotton because of reduced competition for space and nutrient among low populated plants. Varietal effect has also contributed to the weight of the seed/boll. Samcot-13 produced the largest seeds weight/boll which resulted in higher seed yield/boll. This may be due to genetic character of the variety and environmental factors.

Seed yield based on per hectare basis was significant at various N rates, plant densities and varieties. Main effect of nitrogen rates, variety and plant density on seed yield is presented in Figure 7a. Application of nitrogen rate at 150 kg N/ha produced the highest yield of 715.25 kg/ha compared with 686.71 kg/ha for 200 kg N/ha, 412.67 kg/ha seed for 120 kg N/ha and 193.26 kg/ha for control plots.

For variety; Samcot-13 produced the highest seed yield of 550.75 kg/ha followed by 513.91 kg/ha for Jalingo Local and 453.36 kg/ha for Sketch-8 (Figure 7b). Differences in seed yield under plant density was also highly significant, low density (44,444 plants/ha) produced higher seed yield of 551.64 kg compared with 460.71 kg for higher density (60,000 plants/ha) (Figure 7c).

The highest seed yield of 715.25 kg/ha obtained in this study was however, lower than the seed yield of 751.47, 787.09, 832.08 and 777.94 kg/ha obtained by Iren[4] when 150, 200, 250 and 300 kg N/ha in cattle manure,respectively was used in cotton cultivation in Jalingo, Nigeria. In this study, maximum lint yield was obtained at 200 kg N/ha which was statistically at par with 150 kg N/ha, while maximum seed yield was obtained at 150 kg N/ha suggesting that nitrogen rate of 150 kg N/ha was economically best to optimize both lint and seed yield in cotton.

Similar results have been reported by (Muhammed and Javed, 2006; Howard *et al*., 2001; Saleem *et al*., 2011; Muhammed and Nazim, 2012).

3. 1. 3. Number of seeds/boll

Number of seeds per boll was affected by nitrogen rates, variety and plant density. Nitrogen rates of 150 kg N/ha gave the highest number of seeds (26.80) per boll, Samcot-13 variety gave the highest number of seeds (26.71) per boll while low plant density with planting distance of 75 cm by 30 cm (44,444 plants/ha) significantly produced the highest number of seeds (Figures 8a, b and c).

Interactively, the number of seeds was highest under the treatment combination of Samcot-13 × low density (Figure 9a). A combination of 150 kg N/ha with higher density (60,000 plants/ha) and samcot-13 gave the highest seed number (30.71) per bollcompared to lowest seed number of 21.74 seeds per boll at 200 kg N/ha with higher density under Jalingo Local (Figure 9b).

It was evidence from the result on number of seed per/boll that there was a significant difference in seeds number per boll with varying nitrogen levels and variety. The 150 kg N/ha rate was proved to be optimum for seed number per/boll while samcot-13 significantly produced the highest number of seeds/boll.

Low density also had the most seed number/boll because of the larger boll arising from widely spaced plants, hence in this study lower density of 44,444 plants/ha had the highest number of seeds/boll relative to higher density (60,000 plant/ha).

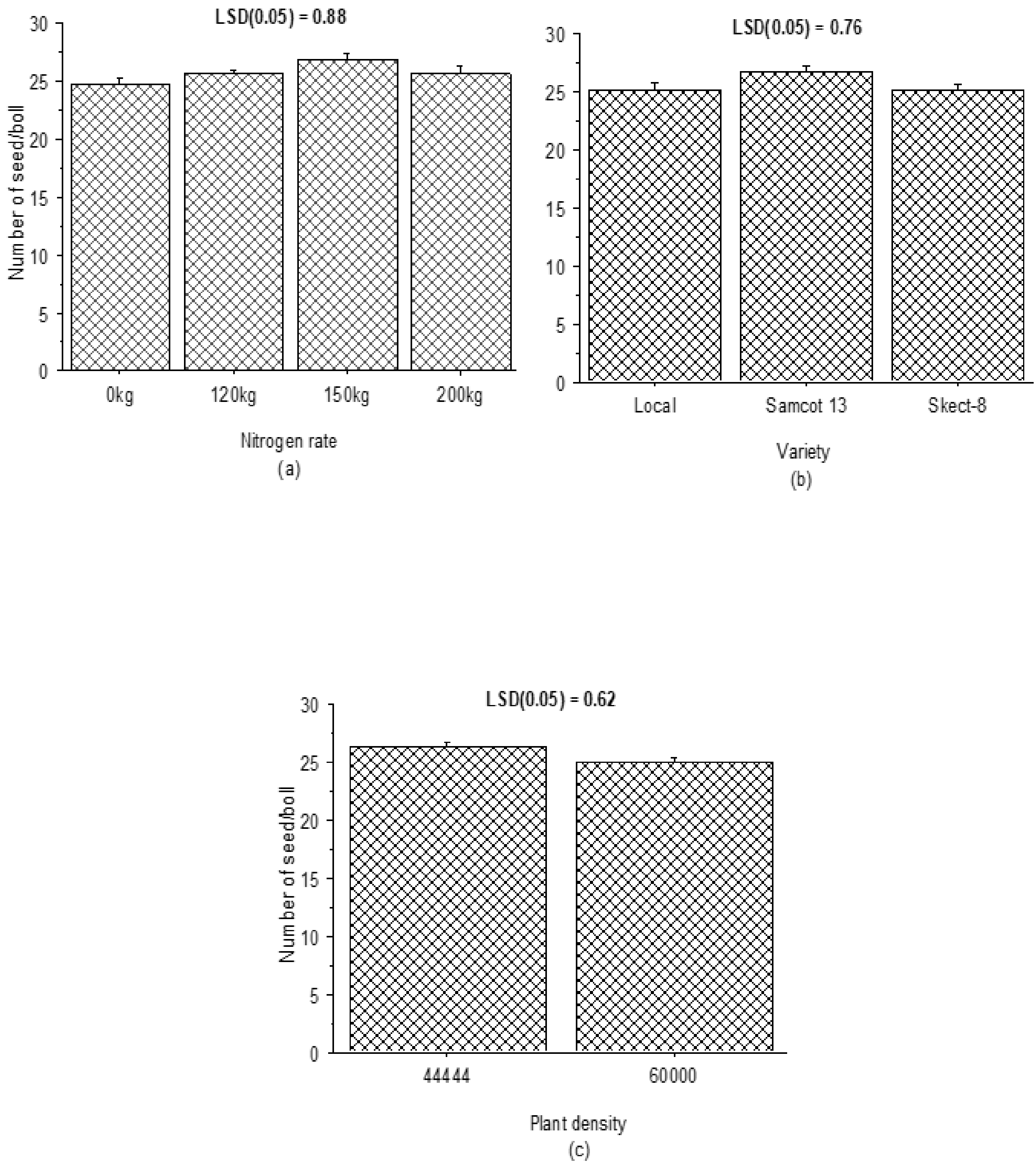


Fig. 8. Effects of (a) nitrogen rates, (b) variety and (c) plant density on number of seed per boll

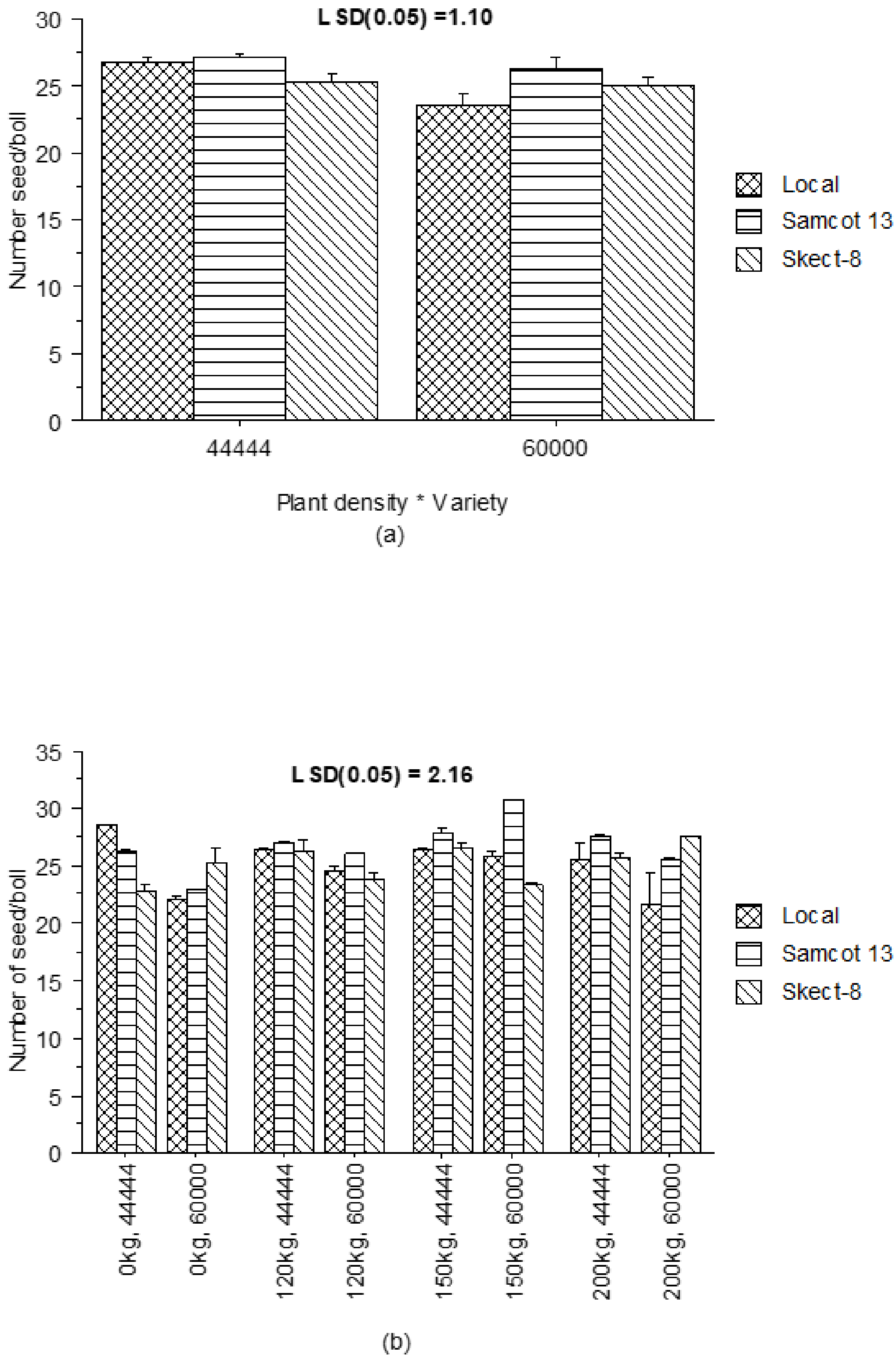


Fig. 9. Interactive effects of (a) plant density * variety and (b) nitrogen *plant density * variety on number of seeds per boll

4. CONCLUSIONS

Nitrogen rate, plant density and variety had positive effects on cotton seed yield, lint yield and number of seeds/boll. Nitrogen rates at all levels significantly increased the seed and lint yield of cotton cultivars when compared with control. However, the differences in yield between 150 kg N/ha and 200 kg N/ha rate was not significant making nitrogen rate of 150 kg N/ha more economical and optimum for cotton seed yield. Low plant population gave rise to higher seed yield. Interactively, the 150 kg N/ha × Jalingo Local × low plant density (44,444 plants/ha) gave the highest cotton seed and lint yield.

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