Effect of plant spacing on pigeonpea grain yield in Northern Uganda

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Abstract

The aim of crop production is to achieve the highest possible yield per unit area. One way of increasing productivity per unit area is through plant spacing optimization. The effect of plant spacing (90 cm x 60 cm, 150 cm x 120 cm and 150 cm x 180 cm) on yield of three pigeonpea genotypes (KAT 60/8, ICEAP 00540 and ICEAP 00554) was investigated on-station in a small-plot field experiments in 2018. Significant differences were recorded in grain yield of all the three genotypes. The highest yield for all the three genotypes was recorded for row spacing of 90 cm and inter plant spacing of 60 cm, and the lowest for row spacing of 150 cm and inter plant spacing of 180 cm. Plant spacing effect on other yield parameters (number of pods per plant and 100 seed weight) were not significant. Similar effects were recorded for plant growth parameters (plant height and number of primary branches). Thus, it can be concluded that row spacing of 90 cm and interplant spacing of 60cm is appropriate for pigeonpea grain production in Uganda.

Keywords: pigeonpea, plant spacing, grain yield.

Efeito do espaçamento entre plantas no rendimento de grãos de feijão bóer no Norte de Uganda

Resumo

O objetivo da produção agrícola é atingir o maior rendimento possível por unidade de área. Uma forma de aumentar a produtividade por unidade de área é através da otimização do espaçamento entre plantas. O efeito do espaçamento entre plantas (90 cm x 60 cm, 150 cm x 120 cm e 150 cm x 180 cm) no rendimento de três genótipos de feijão bóer (KAT 60/8, ICEAP 00540 e ICEAP 00554) foi investigado na estação em uma pequena – parcela de experimentos de campo em 2018. Diferenças significativas foram registradas no rendimento de grãos de todos os três genótipos. A maior produtividade para os três genótipos foi registrada para espaçamento entre linhas de 90 cm e espaçamento entre plantas de 60 cm, e a menor para espaçamento entre linhas de 150 cm e espaçamento entre plantas de 180 cm. O efeito do espaçamento entre plantas sobre outros parâmetros de produção (número de vagens por planta e peso de 100 sementes) não foi significativo. Efeitos semelhantes foram registrados para parâmetros de crescimento das plantas (altura das plantas e número de ramos primários). Assim, pode-se concluir que o espaçamento entre linhas de 90 cm e o espaçamento entre plantas de 60 cm é apropriado para a produção de grãos de feijão bóer em Uganda.

Palavras-chave: feijão bóer, espaçamento entre plantas, produtividade de grãos.

1. Introduction

Pigeonpea is an important food legume in Uganda because of its local consumption as well as huge demand in regional and international export markets (Namuyiga et al., 2022). It provides cheap source of vegetable protein to meet the protein dietary requirements of a large number of rural poor especially women as well as children who do not get required protein at key development stages. Pigeonpea has an ability to fix atmospheric nitrogen and hence less in-organic fertilizer requirement. It is a deep-rooted crop with tolerance to drought (Kumar et al., 2017; Singh et al., 2020), grows on residual moisture conditions and adds resilience to cropping systems (Zapata et al. (2017).

Despite its high value, pigeonpea had received less research attention and consequently yields are lower than achievable in this crop. The present production is about 93,930t with productivity of 894kg/ha^{-1}. This productivity is much lower than the yield potentials exist in this crop. Factors contributing to low yields include farmers' growing landrace varieties, pests and diseases, poor agronomic and poor post-harvest practices. Furthermore, farmers are getting low farm gate price due to the long value chain and yet domestic, regional and international market prices are high (Mergeai et al., 2001; Fatokimi; Tanimonure, 2021).

Plant spacing and population density affect crop productivity and nutritional value (Mekonen et al. 2022). Changes in plant spacing and plant density affect plant growth (Heitholt and Sassenrath-Cole, 2010). Planting pigeonpea with a high plant density has been reported to result in a greater leaf area index, thereby improving light interception and radiation use efficiency (Worku and Demisie, 2012). Rachaputi et al. (2018) reported higher above-ground biomass yield of pigeonpea with narrow row spacing.

Good agronomic practices including appropriated plant population is known to yield and yield components (Meena et al., 2015). According to Swathi et al. 2017, optimum plant density facilitates maximum exploitation of soil moisture, sunlight and nutrients for optimum yield. Limited information exists in literature on the performance of pigeonpea under different row and inter plant spacing in northern Uganda. Hence, the objective of the current study was to investigate the effect of row and inter plant spacing on pigeonpea plant growth parameters and grain yield.

2. Materials and Methods

2.1 Study area

The experiment was conducted between April 2018 and December 2018 at Ngetta Zonal Agricultural Research and Development Institute (02˚17′44″ N and 032˚55′8″ E). The soil type in the study area is sandy loam, and rainfall is bimodal with one peak during April-June and the other in August- November.

2.2 Plant materials

Three medium duration pigeonpea genotypes, ICEAP 00540, ICEAP 00554 and KAT 60/8 were used for field experiments. KAT 60/8 is a released variety. ICEAP 00540 and ICEAP 00554 are elite pigeonpea lines. Seeds were for 2017b planting season. Seed testing was done to confirm seed viability purity. Germination of all the three genotypes was above 90%.

2.3 Experimental design

A randomized complete block design with split-plot arrangement (3 replications) was adopted for the field experiment. Three plants spacing (90 cm x 60 cm, 150 cm x 120 cm and 150 cm x 180 cm) were randomly assigned to whole plots within each block. Each whole plot was divided into three sub-plots, in which the different pigeonpea genotype (ICEAP 00540, ICEAP 00554 and KAT 60/8) were randomly assigned. Plot size was 6 m x 4 m. 2018a season experiment was plant in April 2018 and 2018b season experiment in August 2018. Recommended agronomic and pest management practices were followed. Common insect pests including thrips, pod sucking bugs and pod borers were managed using 4 rounds of insecticide sprays. Data was collected on; a) plant height (cm), number of primary branches, number of pods per plant, 100 seed weight (g) and grain yield (kg/hectare). Plant height was recorded on 5 randomly sampled plants per plot in cm at physiological maturity, and number of pods from 5 randomly selected plants per plot at harvest;

2.4 Statistical analysis

Data on plant height, number of primary branches, number of pods per plant, 100 seed weight and grain yield were analysed by analysis of variance (ANOVA) assuming normal distribution Data analysis was performed using GENSTAT statistical package 16th edition. The data were subjected to ANOVA, and residual plots were used to check ANOVA assumptions. Hypotheses were rejected at $P \leq 0.05$ and means compared by *Turkey's* test. Mean values of results presented. 2018a and 2018b season experiments were analyzed together as there were no interactions between treatment and experiment.

3. Results

3.1 Effect of plant spacing on pigeon pea grain yield

The result for the effect of plant spacing on pigeon pea grain yield is presented in (Table 1 and Table 2). Significant differences (*P* <.0.01) were observed in grain yields of the three pigeonpea genotypes (Table 1).

Table 1. ANOVA for the effect of plant spacing on grain yield.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication stratum	6	2988478	498080	2.14	
Replication.*Units* stratum					
Varieties	2	1217391	608695	2.61	0.084
Plant spacing	2	6458036	3229018	13.86	<.001
Varieties x spacing	4	143641	35910	0.15	0.96
Residual	48	11181128	232940		
Total	62	21988673			

Note: d.f = degrees of freedom, s.s = sum of squares, m.s = mean square, v.r = variation, Fpr = F-statistics.

Significantly higher grain yields were recorded at row spacing of 90 cm and inter plant spacing of 60 cm for all the three genotypes in kilograms per hectare (ICEAP 00540-2308, ICEAP 00554-2193 and KAT 60/8-1888) and the lowest at a spacing of 150 cm x 180 cm ((ICEAP 00540-1523, ICEAP 00554-1327 and KAT 60/8-1267) (Table 2). Variety effect was not significant (*P* = 0.084). Similarly, the effect of plant spacing on number of pods per plant and the weight of 100 seeds were not significant (*P* $\geq$ 0.05).

Table 2. Plant spacing effect on yield parameters.

Plant spacing	No. of Pods Plant^{-1}				100 seed weight (g)				Grain Yield (Kgh^{-1})			
	A	B	C	LSD (5%)	A	B	C	LSD (5%)	A	B	C	LSD (5%)
ICEAP 00540	337	322	277	NS	13	11.57	13	NS	2308	1677	1523	590.6
ICEAP 00554	333	309	358	NS	13.71	12.86	13.43	NS	2193	1513	1327	435.5
KAT 60/8	300	254	259	NS	12.71	12.43	12.71	NS	1888	1433	1267	437.4
LSD (5%)	NS	NS	NS		NS	NS	NS		NS	NS	NS	

Note: NS = Not significant.

3.2 Effect of plant spacing on pigeonpea growth parameters

The result for the effect of plant spacing on pigeon pea growth parameters is presented in (Tables 3 and 4). Plant spacing effect on plant height and number of primary branches were not significant (*P* $\geq$ 0.05) (Table 3). Pigeonpea genotype effect was also not significant (*P* $\geq$ 0.05).

Table 3. ANOVA for the effect of plant spacing on plant growth.

Source of variation	Plant Height					No. of primary branches			
	d.f	s.s.	m.s.	v.r.	F pr.	s.s.	m.s.	v.r.	F pr.
Replication stratum	6	121748.1	20291.4	80.08		285.101	47.517	7.43	
Varieties	2	882.4	441.2	1.74	0.186	18.93	9.465	1.48	0.238
Spacing	2	186.4	93.2	0.37	0.694	24.423	12.211	1.91	0.159
Varieties x spacing	4	454.2	113.5	0.45	0.773	11.356	2.839	0.44	0.776
Residual	48	12163	253.4			307.105	6.398		
Total	62	135434.1				646.914			

Notes: d.f = degrees of freedom, s.s=sum of squares, m.s = mean square, v.r = variation, Fpr = F-statistics.

Plant height ranged from 166.2 to 148.3cm, and number of primary branches from 14.63 to 12.77 (Table 4).

Table 4. Effect of plant spacing on plant height and number of primary branches.

Plant spacing	Plant Height (cm)				No. of primary branches			
	A	B	C	LSD	A	B	C	LSD
ICEAP 00540	166.2	160.9	163.3	NS	14.31	13.89	14.54	NS
ICEAP 00554	159	156.8	163.3	NS	14.46	12.57	14.61	NS
KAT 60/8	148.3	156.5	158.2	NS	12.77	12.54	13.63	NS
LSD	NS	NS	NS		NS	NS	NS	

Note: A = plant spacing: 90 cm x 60 cm, B = plant spacing: 150 cm x 120 cm, C- = plant spacing: 150 cm x 180 cm, NS = Not significant.

4. Discussion

Plant height and number of primary branches at harvest did not vary significantly for ICEAP 00540, ICEAP 00554 and KAT 60/8 genotypes for the three row spacing and inter plant spacing tested. The lack variability could be attributed to the adequacy of rainfall and temperature for pigeonpea growth at the test location (Mishra et al., 2017) and the physico-chemical characteristics of the soil (Behera et al., 2020). Plant height was not affected by plant density. Similar observations have been reported for *Hibiscus cannabinus* L. (Reta-sánchez et al., 2010) and pigeonpea. This observation is contrary to what was reported by Singh et al. 2014, where narrow plant spacing, increased the plant height of Petunia as a result of the competition for light (Drummond et al., 2015) and improved water use efficiency (Zhou et al., 2010). It therefore, means that even at the lowest spacing of 90cm x 60cm light and moisture were adequate, and did not affect plant growth parameters.

In the current study, the number of primary branches did not significantly differ among the genotypes for the three plant spacing tested. This could be attributed partly to low or no competition for light. Additionally, the lack of variability in branching may also be associated with availability in adequate amounts soil nutrients especially nitrogen and phosphorus. Nitrogen and Phosphorus have been reported to limit plant branching (Drummond et al., 2015). According to Katayama et al. 1999, nitrogen fixation by pigeonpea alone may not satisfy the nitrogen requirements of pigeon pea, therefore, adequate soil nitrogen might have contributed to pigeonpea branching patterns observed (Osada, 2013). Although row and inter plant spacing is among the factors that affect the number of branches in pigeon pea, branching was not affected in the current study.

Furthermore, the narrower row spacing (90 cm) and lesser inter plant spacing (60 cm) gave higher grain yield than the wider spacing of 150 cm x 120 cm and 150 cm x 180 cm. Since the number of pods per plant was not significantly different for the three genotypes, it implied the three spacing were ideal for pigeonpea growth. The significantly higher grain yield for the row spacing of 90cm and interplant spacing of 60 cm could be attributed to the very high plant density. The plant density for 90 cm x 60 cm was 18,519 plants/hectare, compared to 5,556 plants/hectare and 3,704 plants hectare^{-1} for 150 cm x 120 cm and for 150 cm x 180 cm, respectively. However, the effect of decreasing both the row spacing and inter plant spacing below 90 cm x 60 cm needs to be studied further. Based on the results of the current study, the combination of row spacing of 90cm and interplant spacing of 60 cm with a plant density of 18,519 plants hactre is recommended for grain production.

5. Conclusions

Grain yield did not vary significantly for all the three pigeonpea genotypes at plant spacing of 90 cm x 60 cm, 150 cm x 120 cm and 150 cm x 180 cm, respectively. Significantly higher grain yields were obtained for the three genotypes at 90 cm x 60 cm. The narrower spacing of 90 cm x 60 cm produced higher yields as a result of increased plant population and good plant growth performance. Therefore, from this study, we can conclude that the row spacing of 90 cm and inter plant spacing of 60 cm with a plant population density of 7,407 plants/ hactare is ideal for the production of pigeonpea grains in northern Uganda.

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7. Authors' Contributions

Kumakech Alfred: responsible for the ideas, formulation, and evolution of the objectives of the research, carrying out experiments, statistical analysis and writing the original draft. *Opio Tonny*: data collection, *Laban Frank Turyagyenda*: supervision and review of the research work.

8. Conflicts of Interest

No conflicts of interest.

9. Ethics Approval

Not applicable.

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