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# Yield and fruit quality of okra *(Abelmoschus esculentus L.* Moench) in response to plant density

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**Abstract**

A greenhouse study was conducted from February - May 2013 at Kent Estate, Harare, Zimbabwe, to determine the influence of plant density on growth and yield of okra cv. 'Clemson Spineless'. The trial was laid out in a Randomised Complete Block design (RCBD) using 4 replications. Five levels of plant density viz. 20 800 plants ha$^{-1}$, 31 200 plants ha$^{-1}$, 41 600 plants ha$^{-1}$, 52 000 plants ha$^{-1}$, and 62 400 plants ha$^{-1}$ were used as treatments. Data collected was statistically analyzed using Analysis of variance (ANOVA). The Least Significant Difference (LSD) was used for mean separation ($P < 0.05$). Tallest plants were recorded from plant density of 62 400 plants ha$^{-1}$ whilst shortest plants were recorded at plant density of 20 800 plants ha$^{-1}$. Plant density of 31 200 plants ha$^{-1}$ produced the highest number of branches whilst plant density of 62 400 plants ha$^{-1}$ recorded the lowest number of branches. The highest number of pods was recorded at plant density of 31 200 plants ha-1 whilst the lowest pod number was recorded at plant density of 62 400 plants ha$^{-1}$. Pod length generally decreased as plant density increased with longest and lowest pods recorded at 20 800 and 62 400 plants ha-1 respectively. The highest fruit fresh yield was recorded from plant density of 31 200 plants ha$^{-1}$ whilst the lowest was recorded from 62 400 plants ha-1. Results of the study showed that plant density of 31 200 plants ha$^{-1}$gives the highest yield in okra variety 'Clemson'.

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## Introduction

Okra *(Abelmoschus esculentus* (L.) originated in Asia and Africa and it is an important vegetable grown in tropical and subtropical parts of the world (Absar and Siddique, 1992; Baloch, 1994). Okra also known as Lady`s finger is considered economically important in Nigeria (Farinde *et al*., 2007). Okra is solely grown for its immature pods which can be harvested over a long period of time if well managed (Maurya *et al*., 2013). The pods are harvested regularly for best yields and leaving the pods to mature on the plant will reduce flowering and reduce further pod production (Ekwu and Nwokwu, 2012). The importance of okra has the potential to improve due to increase in vegetable consumption due to health concerns around the world. Okra is nutritionally rich in carbohydrates, Vitamins A, B1 and C (Lee *et al*., 2000; Ekwu and Nwokwu, 2012; Rashwan, 2011), calcium, potassium and dietary fibre (Rashwan, 2011). In Zimbabwe, okra is used as a form of relish and its production is wholly by small scale farmers and its economic importance lies in internal trade. Okra boosts local economies in areas around Birchnough Bridge in Zimbabwe where communal farmers produce it in bulky quantities for a living. Furthermore, okra is among the major crops in irrigation schemes in the highlands of Zimbabwe where it is a significant source of income to most communal farmers in that area. Okra like most local vegetables has so far received very limited research attention in Zimbabwe since most research work on horticulture has focused on the large-scale commercial sector and the small-scale sector has somehow been neglected (Turner and Chivinge, 1999). As such, okra production has mostly been confined to open field production since greenhouse production has been associated with those crops given more attention. Greenhouse production usually comes with both high production output and quality because of the greenhouse structures providing favourable conditions for plant growth and development (Critten and Bailey, 2002).

Previous studies on okra production have highlighted sowing time (Talukder *et al*., 2003), sowing depth (Ijoyah *et al.,* 2012) and plant spacing (Ekwu and Nwokwu, 2012) among others as factors affecting the productivity and quality of the crop among which plant density plays a significant role (Maurya *et al*., 2013). However, in Zimbabwe planting of okra seeds is done by randomly hand digging holes without paying attention to plant spacing. This has an implication of yield and fruit quality of okra (Yadev and Dhankhar, 2005). Absar and Siddique (1992) also highlighted the importance of plant density in the production and yield of okra. Incorrect plant spacing results in low yield and poor quality fruits (Moniruzzaman *et al*., 2007). Furthermore, high plant densities may lead to rigorous growth, poor quality fruits and low yield due to intra specific competition (Talukder *et al*., 2003). In addition, a significant decrease in pod yield was also observed as a result of increased plant density (Dikwahal *et al*., 2007; Gupta, 1990). Increasing plant density generally increases yield per unit area till a certain limit (Weiner, 1990). The possibility of increase in okra production and consumption in Zimbabwe calls for a need to ascertain a plant density that gives the best yield and fruit quality of okra. This study was therefore carried out to determine the response of growth rate and yield of greenhouse grown okra to varying plant densities.

## Materials and methods

The study was conducted at Kent Estate from February - May 2013. Kent estate is located 15 km north east of Norton in Zimbabwe with an altitude of 1400m above sea level in natural region iia. Kent estate receives a mean annual rainfall of about 750-1000mm. The soils are predominantly red clay soils. The okra seeds of cultivar 'Clemson Spineless' were used for this study. Five levels of plant density viz. D1 (20 800 plants $ha^{-1}$), D2 (31 200 plants $ha^{-1}$), D3 (41 600 plants $ha^{-1}$), D4 (52 000 plants $ha^{-1}$), and D5 (62 400 plants $ha^{-1}$ were used. The five treatments were laid out in a in a Randomized Complete Block Design (RCBD) replicated four times. Land preparation included deep digging of the soil followed by preparation of beds. Finally the beds were levelled using and prepared to fine tilth using a flat plank. Four beds were prepared and divided into five plots each with an area of $2.5m^2$. Compound D (7N:14P:7K) was applied as a basal fertilizer at a rate of 150 kg per hectare before planting. Ammonium nitrate (34.5N) was applied as top dressing at a rate of 290 kg per hectare through fertigation, potassium nitrate was applied every fortnight at a rate of 25 kg per hectare. Seeds were soaked for 24 hours before planting to hasten germination. Three seeds were sown per planting station and later thinned to one plant at two weeks after planting. Scouting was carried out for plant population after emergence, weed infestation, cutworm and damping off on seedlings and other insect pests and diseases. The weeds were controlled by hoeing and hand pulling as need arose. The plants were irrigated via drip irrigation 3 times a week. Karate was applied before planting using a mist blower at a rate of 200 ml per hectare to control cutworm (*Agrotis spp*). Tamaron (active ingredient: methamidophos) was applied for the control of leaf miner. Powdery mildew was controlled through the application of wettable sulphur. Harvesting was done three times a week.

*Data collection*

Data collected includes plant height at 50% flowering (measured as the distance in cm from the soil surface to the tip of the topmost leaf), number of branches per plant, pod length (length was measured as the distance in cm from the fruit cap scar at the base to the tip end of the pod), number of pods per plant and fresh yield (tonnes/ hectare).

*Statistical analysis*

All data were statistically analyzed using the Analysis of variance (ANOVA) and the Least Significant Difference (LSD) was used for mean separation ($P < 0.05$) as outlined by Steel and Torrie (1980).

## Results and discussion

*Effect of plant density on plant height*

There was a significance difference ($P < 0.05$) in plant height at 50% flowering among different plant densities (Table 1). The tallest plants (99.2 cm) were recorded in the plant density of 62 400 plants ha$^{-1}$ but this was statistically similar to the plant density of 52 000 plants ha$^{-1}$. These results are in close conformity with the findings of Hossain *et al.* (2001). The shortest plants (76.1 cm) were obtained in the plant density of 20 800 plants ha$^{-1}$ and were not significantly different from those grown at 41 600 and 31 200 plants ha$^{-1}$. Plant height increased with increase in plant density. The tallest plants produced by the most densely populated plants might be attributed to the competition for light and other growth resources among the plants that were crowded at the closer plant spacing (Maurya *et al.*, 2013). This may be attributed to the close spacing of 30 cm along the row which made the crops to be crowded, possibly because of intra competition for light and other growth resources (Ibeawuchi *et al.*, 2005).

**Table 1.** Effect of plant density on vegetative growth characteristics and yield of okra.

| Plant density (Plants ha$^{-1}$) | Plant height (cm) | Number of branches | Number of pods per plant | Pod length (cm) | Total fresh yield (Tonnes ha$^{-1}$) |
|---|---|---|---|---|---|
| 20 800 | 76.1a | 7.33c | 20.68d | 9.38c | 12.15bc |
| 31 200 | 80.2a | 8.28d | 21.90c | 8.25b | 13.62c |
| 41 600 | 81.9a | 6.78bc | 17.95b | 8.60bc | 11.08b |
| 52 000 | 95.5b | 6.15ab | 17.40b | 6.72a | 9.55a |
| 62 400 | 99.2b | 5.70a | 15.25a | 6.57a | 8.93a |
| Mean | 86.1 | 6.85 | 18.64 | 7.90 | 11.07 |
| LSD $_{(0.05)}$ | 8.58 | 0.831 | 1.072 | 1.118 | 1.438 |
| F Prob | <.001 | <.001 | <.001 | <.001 | <.001 |
| CV% | 6.4 | 7.9 | 3.7 | 9.2 | 8.4 |

Key: Means followed by same letters are not significantly different ($P \leq 0.05$).

*Effect of plant density on number of branches*

Plant density had a significant effect ($P < 0.05$) on the number of branches produced per plant (Table 1). Plant density of 31 200 plants ha$^{-1}$ had the highest number (8.28) of branches per plant whilst plant density of 62 400 plants ha$^{-1}$ had the lowest number

(5.7) of branches per plant. Plant densities of 52 000 plants $ha^{-1}$, 41 600 and 20 800 plants $ha^{-1}$ were intermediate and not significantly different from each other. The number of branches per plant reached maximum at 31 200 plants $ha^{-1}$ and thereafter declined with a decrease in plant density probably because of less light interception at the lowest plant density (62 400 plants $ha^{-1}$). This observation is similar to that of Muoneke and Asiegbu (1997) who found that the number of branches of okra intercropped with maize decreased with increasing plant density. The reduced competition for light and other resources as well as reduced overlap from adjacent plants possibly resulted in plants utilizing their energy for maximum branching (Saha *et al.*, 2005).

*Effect of plant density on number of pods produced per plant*

There were significant differences ($P < 0.05$) on the number of pods per plant (Table 1). Plant density of 31 200 plants $ha^{-1}$ produced the highest number (21.9) of pods per plant whilst plant density of 62 400 plants $ha^{-1}$ had the lowest number (15.25) of pods per plant. Plant density of 52 000 plants $ha^{-1}$ and 41 600 plants $ha^{-1}$ and 20 800 plants $ha^{-1}$ were intermediate and were not significantly different from each other. The highest number of pods per plant produced from plant density of 31 200 plants $ha^{-1}$is most likely because the highest number of branches per plant was also obtained from the same plant density and might have also contributed to its greatest number of pods produced due to increased growing points. This was probably because at lower plant density, plants receive more nutrients and lateral growth takes place resulting in increased number of pods per plant. The findings are in close conformity with those reported by Amjad *et al.* (2001) who observed that a plant density of 37 000 plants $ha^{-1}$ resulted in the maximum number of mature pods per plant compared to higher plant densities used. A similar observation was made by Ekwu and Nwoku (2012) also reported a higher number of pods produced per plant at wider plant spacing suggesting that less competition for nutrients and space among the plants resulted in more pods being produced.

*Effect of plant density on pod length*

Plant density had a significant effect ($P < 0.05$) on pod length (Table 1). The longest pods (9.38 cm) were obtained from plant density of 20 800 plants $ha^{-1}$. Plant density of 62 400 plants ha $^{-1}$ had the shortest pods (6.57 cm) but was not significantly different from those produced from pant density of 52 000 plants $ha^{-1}$. Plant density of 41 600 plants $ha^{-1}$ and 31 200 plants $ha^{-1}$ were intermediate and not significantly different from each other. The lengths of fresh pods decreased as the plant density increased. These results concur with the findings of Talukder *et al.* (2003) and Ekwu and Nwokwu (2012) who also recorded the longest pods at the widest plant spacing. This might be attributed to availability of sufficient nutrients, moisture and sunlight per plant at a lower plant density (Maurya *et al.*, 2013). The wider spaced plants were possibly translocating more of their photo assimilates into their fruits making them larger and heavier than those produced by plants in the closest and intermediate spacing.

*Effect of plant density on total fresh yield*

Plant density had a significant effect ($P < 0.05$) on total yield of fresh fruits (Table 1). The highest fresh fruit yield (13.62 tonnes $ha^{-1}$) was obtained from plant density of 31 200 plants $ha^{-1}$. Plant density of 62 400 plants $ha^{-1}$ had the lowest yield (8.93 tonnes $ha^{-1}$). Plant density of 41 800 plants $ha^{-1}$ and 20 800 plants $ha^{-1}$ were not significantly different from each other but they were significantly different from plant density of 52 000 plants $ha^{-1}$. The results are in close conformity to those reported by Maurya *et al.* (2013) who observed the highest yield at the highest plant spacing of 60 x 45 cm. As plant density increased from 20 800 plants $ha^{-1}$ to 31 200 plants $ha^{-1}$ the yield also increased and then decreased as plant density was further increased. The increase of yield with plant density to a certain level and then a decrease and this concurs with the findings reported by Weiner (1990) who observed that increasing plant density increases yield to a certain limit. The lowest yield from the highest plant density of 62 400 plants ha$^{-1}$ is most probably due to intra specific competition (Talukder *et al.*, 2003) of assimilates. In addition, a higher yield produced by closely spaced plants is more likely due to the higher number of plants accommodated by the closer spacing (Maurya *et al.*, 2013). The findings of this study are almost similar to those reported by Hossain *et al.* (2001).

**Conclusion**

Results from the study show that a plant density of 31 200 plants ha$^{-1}$ is the optimum plant density for okra production. Farmers who embark on okra production are advised to use the plant density of 31 200 plants ha$^{-1}$ to ensure maximum yield of the crop.

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