Research Article

Study to Determine the Effects of High Density Plantation on Growth and Yield of Citrus

Waqas Ahmed Dogar[2], Arshad Ali Khan[3*], Saeed Ahmed[2], Sudheer Tariq[2], Mukhtar Ahmad[2], Muhammad Imran[2], Muhammad Noman[2] and Nadeem Khan[1]

[1]Department of Agriculture, Abdul Wali Khan University, Mardan; [2]Department of Horticultural Research and Development, NARC Islamabad; [3]BRAINS Institute, Peshawar, Khayber Pakhtunkhawa, Pakistan.

Abstract | A field trial was conducted to evaluate the effects of high density plantation on growth and yield of citrus (Kinnow and Musambi) grown under drip irrigation at Postgraduate Agriculture Research Station (PARS) Institute of Horticultural Sciences, University of Agriculture Faisalabad. Plants were grown at three planting distances as T_1 (11 x 22ft), T_2 (11 x 11ft) and T_3 (22 x 22ft). T_1 (11x22ft) was optimum plantation and showed best results for yield. Maximum fruit yield per plant (3.6373 kg) was observed from the same plants. T_2 (11 x 11ft) was close plantation and had more total number of flowers per plant (441.58) and fruit length (58.243 mm), but yield was less due to more fruit drop % (74.165). While, T_3 (22 x 22ft) exhibited the poorest results. V_2 (Musambi) showed best results for most parameters. Overall situation indicated that plants planted at 11 x 22ft (T_1) showed better results as compared to plants planted at 11x11ft (T_2) and 22 x 22ft (T_3) of both species. Musambi showed best results as compared to Kinnow. So this study helped to optimize best planting distance in citrus adopted for high yield and good quality fruit with some extra care and management practices in orchard and proved to be the best planting distance for citrus under agro ecological conditions of Punjab province of Pakistan.

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***Correspondence** | Arshad Ali Khan, BRAINS Institute, Peshawar, Khayber Pakhtunkhawa, Pakistan; **Email:** arshadali41@gmail.com
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Introduction

Citrus plantings should be planned so that the biological and management aspects are interrelated to maximize economic returns. Hutton (1989) reported that changes in labor relations, government regulations, and tree loss rates require continual evaluation of citrus plantings to establish systems. In Florida a number of changes have occurred which affect returns from citrus production; land values and taxes have increased, certain zoning laws favor the agricultural production, availability of good land for citrus has decreased; citrus on poor soil type results in smaller tree size due to various limiting factors, loss of trees due to diseases has increased; and there have been increase in capital expenditures for equipments and irrigation, interest rates and labor costs. Due to these changes, citrus production in future must make more efficient use of limited land that provide more rapid recovery of invested capital in order to provide maximum net return. Zekri (2000) reported that tree spacing has become an increasingly important consideration in citrus rootstock management because of the benefits of higher tree density on early production and financial returns. Phillips (1978) reported that high density plantation may result in getting

earlier return on investment, better spray coverage at less cost and easy harvesting in citrus. Keeping this in view the present study was initiated to find out the appropriate planting distance for citrus groves under the agro ecological conditions of Punjab province of Pakistan.

Materials and Method

The study was carried out at Postgraduate Agriculture Research Station (PARS), Institute of Horticultural Sciences, University of Agriculture Faisalabad during 2012-2014 for the two consecutive years. The laboratory work was carried out at the Pomology Lab., Institute of Horticultural Sciences University of Agriculture, Faisalabad. Five years old 180 trees of Kinnow mandarin and Musambi were planted under drip irrigation of moderate vigor and health grafted on rough lemon rootstock which were grown at three planting distances. The experiment was laid out according to Randomized Complete Block Design (RCBD) with three treatments.

Factor A:
1. Kinnow mandarin
2. Musambi

Factor B:
T_1: Trees at planting distance 11 x 22 ft
T_2: Trees at planting distance 11 x 11 ft
T_3: Conventional planting distance 22 x 22 ft

The present work was under taken by keeping three treatments replicated six times. Treatment units in one treatment (11 x 11 ft) were different, while the other two treatments were kept same. To determine the vigor of the trees, stem girth, plant height, number of new flushes, number of new leaves/flush, number of older leaves/flush, fruit set (%) and yield were measured according to the standard procedure. Girth measurement was taken at a fixed height of 25 cm above the graft union; position was fixed for all the treatments. The measurements were analyzed by the least significant difference. No hedging or pruning of the trees was done. Height of the tree was measured with the help of telescopic pole.

Data of new flushes was taken by counting the number of new flushes from the tagged branches from four sides of the tree. Number of new leaves was counted from the branches tagged in all the four sides of the plant. When bloom was over, fruit set on the selected trees was counted on marked branches in the third week of April 2012. Fruit set percentage was determined by using the following formula:

$$\text{Fruit set (\%)} = \text{Total fruit set} \times 100$$

Total bloom
Yield was recorded by counting the total number of fruits per plant at the time of harvesting.

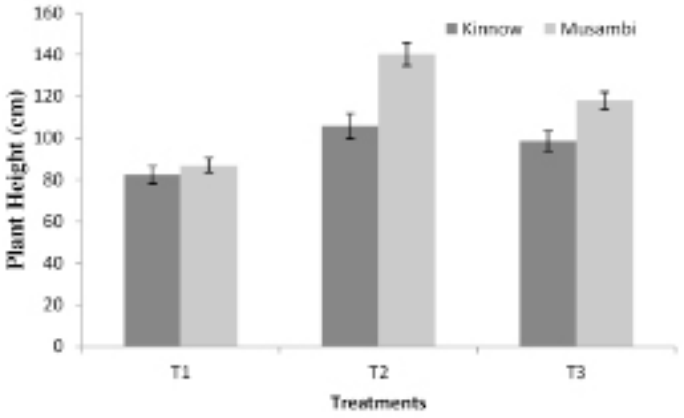

Figure 1: *Effect of plant spacing on plant height of Kinnow and Musambi.*

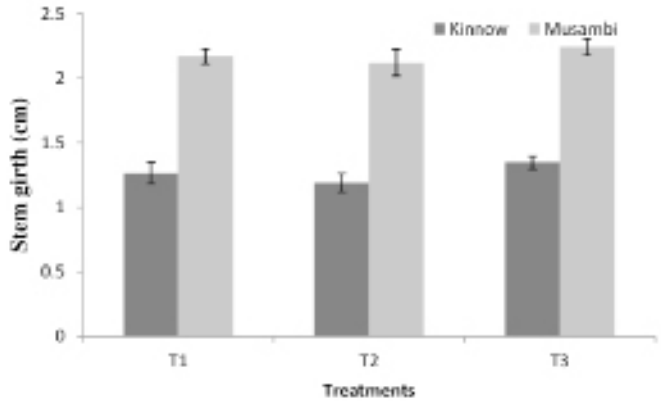

Figure 2: *Effect of plant spacing on stem frith of Kinnow and Musambi.*

Results and Discussion

Plant Height (cm)

Maximum plant height of 123.60 cm was recorded in plants of T_2 (11x11ft) which was significantly higher than the plants of other treatments while minimum plant height (84.73 cm) was measured in plants of T_3 (22x22ft). Maximum plant height of 115.07 cm was recorded in V_2 (Musambi) and that were statistically higher from V_1 (Kinnow) where height was 95.78cm. This is mainly due to the competition for

light in plants at close spacing and shadows effect during morning and evening hours. So naturally for active photosynthetic reaction plant produce terminal branches. Similar results regarding plant height were also reported by Sharma et al. (1992), Athani et al. (2009) and Nasir et al. (2006) who reported that close plantation increased the plant height.

Stem Girth (cm)

Maximum plant girth of 17.943 cm was recorded in plants of T_3 (22x22ft) which was wider spacing and significantly different from plants of other treatments. Minimum stem girth (16.552 cm) was found in plants of T2 (11x11ft). Maximum stem girth of 21.762 cm was recorded in plants of V_2 (Musambi) which was statistically different from the plant of V_1. Minimum stem girth (12.675 cm) was found in V_1. Bassal (2009) reported that stem girth was more in wider spacing as compared to close plantation and main phenomenon of stem girth increased may be due to genetic makeup of plant. In addition to this, our results confirms the finding of Tachibana (1998) who reported that with increase in plant spacing, there was an incremental trend in stem girth in normal spacing as compared to closer spacing.

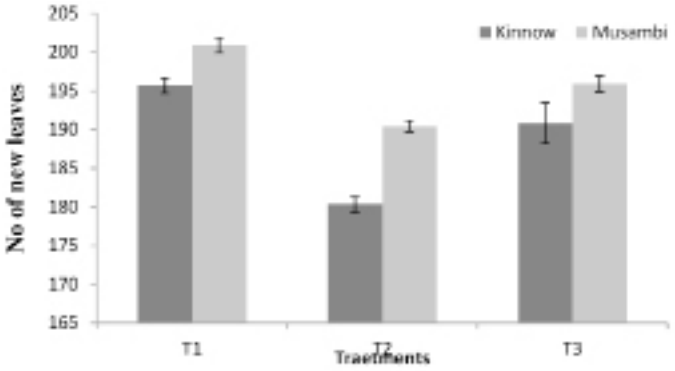

Figure 3: *Effect of plant spacing on number of new leaves of Kinnow and Musambi.*

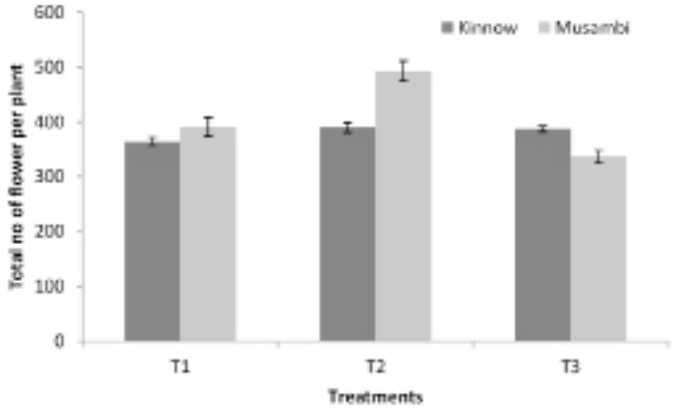

Figure 4: *Effect of plant spacing on total no of flower per plant on Kinnow and Musambi*

Number of new leaves

Maximum new leaves (198.29) were recorded in plants that were transplanted at 11x22ft (T1) and these were significantly higher than the plants of other treatments while minimum new leaves (198.29) were found in plants of T2 (11x11ft). Maximum new leaves of 195.75 were recorded in plants of V_2 (Musambi) and these were statistically more than leaves (188.94) in the plants of V1 (Kinnow). This was mainly due to more light penetration in optimum spacing which promotes vegetative growth. It was found by Nawaz (2007) that light intensity and quality improved the vegetative growth in citrus in optimum plantation.

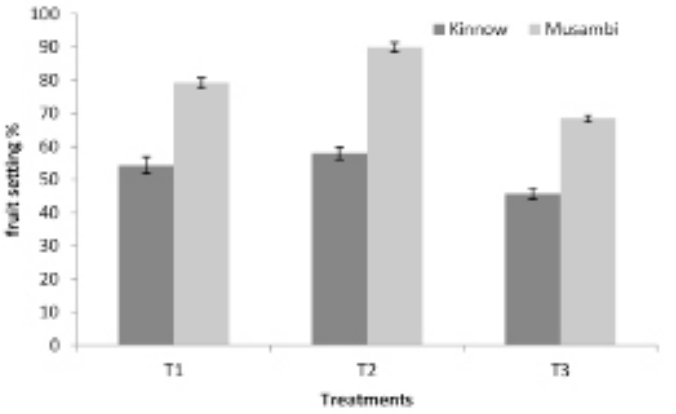

Figure 5: *Effect of plant spacing on fruit setting percentage on Kinnow and Musambi.*

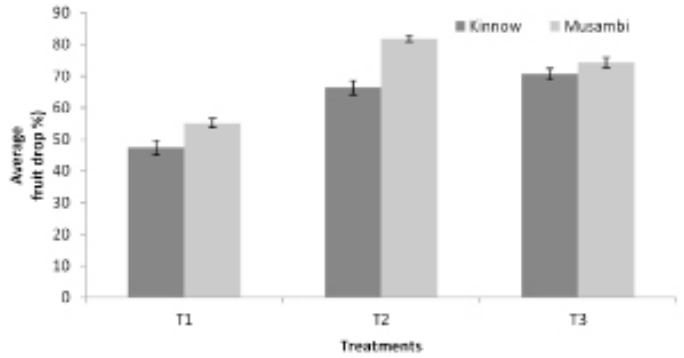

Figure 6: *Effect of plant spacing on fruit drop percentage on Kinnow and Musambi.*

Total number of flower per plant

Maximum flowers per plant of 441.58 were recorded in plants of T_1 (11 x 22 ft) and these were significantly higher from the plants of other treatments. Minimum flowers per plant (361.97) were found in plants of T_2 (11 x 11ft). Maximum numbers of flowers per plant of 406.93 were recorded in plants of V_2 and these were significantly higher than the plants of V_1 (380.59). The interaction effect showed that the plant of V_2 (Musambi) attained maximum no of flowers per plant of 493.13 in T3(11x22ft), while minimum no

of flowers per plant of 336.53 was recorded in plant of V_2 (Musambi) those were planted at (11x11ft). Wider spacing (HDP) increased number of plants per acre as compared to those plants planted at close spacing. Fruit setting is a genetic factor and is directly related to plant nutrients and cultural practices (Khan et al., 2014). It can be concluded that 11 x 22ft plant spacing in Musambi has significant effect on flowers per plant and in close spacing number of flowers per plant were minimum.

Fruit setting percentage

Maximum fruit setting percentage of 74.00% were recorded in plants of T_2 (11x11ft) that were significantly higher than the plants of other treatments. Minimum fruit setting percentages (57.117%) were found in plants of T_3 (22x22ft). Maximum fruit setting percentage of 79.222 was recorded in plants of V_2 and those was statistically higher from V_1, while minimum fruit setting percentage (52.70%) was found in plants of V_1. Our results confirmed the findings of the Nawaz et al. (2007) who reported that fruit setting percentage was increased with decreased plant spacing.

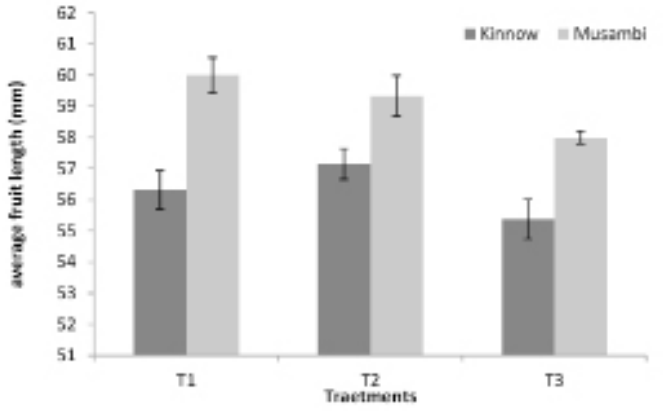

Figure 7: *Effect of plant spacing on average fruit length (mm) on Kinnow and Musambi.*

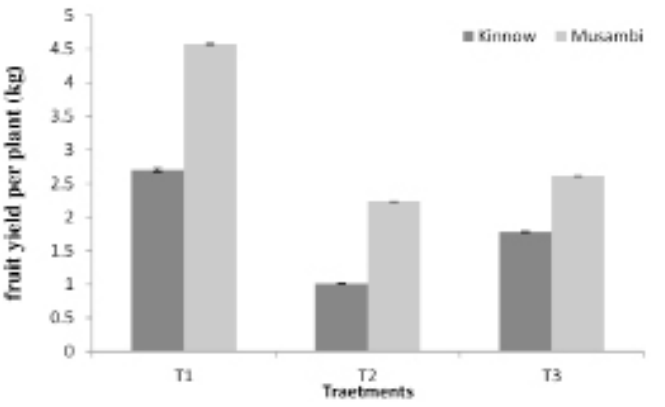

Figure 8: *Effect of plant spacing on of fruit per plant on Kinnow and Musambi.*

Fruit drop %

Fruit drop in tree fruit is a physiological phenomenon often called Natural fruit load sharing. It occurs in many successions from initial fruit set to fruit maturity around the year in citrus. The data for fruit drop were taken in accordance with natural cycle of fruit drop during the month of May, June, July and August 2012-14.

Maximum fruit drop percentages (74.165%) were recorded in plants of T_2 (11x11ft) which were statistically more than the plants of other treatments. Minimum fruit drop percentages (51.334%) were found in plants of T_1 (11x22ft). Maximum average fruit drop percentage of 70.485% was recorded in plant of V_2 (Musambi) that was statistically higher than the plants of V_1 (Kinnow), while minimum fruit drop percentage (61.484) were found in V_1 treatment. The interaction effect showed that the plant of V_2 (Musambi) showed maximum fruit drop percentage of 81.959 in plant of T_2 (11x11ft), while minimum fruit drop percentage of 47.473 was recorded in plant of V_1 (Kinnow) those were planted at (11x22ft) distance.

Fruit length (mm)

Maximum fruit length of 58.243 mm was recorded in plants of T_2 (11x11ft), which was statistically higher than the plants of other treatments. Minimum fruit length (56.688 mm) was found in plants of T_3 (22x22ft). Maximum fruit length of 59.111 mm was recorded in V_2 (Musambi) that was statistically more than the plants of V_1 (Kinnow) (56.283 mm). But interaction effect showed non-significant results.

It can be concluded that 11x11ft plant spacing in Musambi had significantly increased fruit length. In general, length of Musambi was more than Kinnow Mandarin. Similarly Khan et al. (2014) reported that fruit length is directly related to mineral nutrition and also depends on genetic makeup.

Fruit yield per plant (kg)

Among all treatments, on average maximum fruit yield per plant (3.6373 kg) was recorded in T_1 (11x22ft), while minimum was recorded in T_2 (11x11ft), whereas, V_2 gave better fruit yield per plant (3.1395 kg) than V_1 (1.8313 kg). In comparison of both treatments and varieties at T_2 fruit yields per plant were 2.70 and 4.57 kg in V_1 (Kinnow) and V_2 (Musambi), respectively. At T_1 fruit yield per plant was 1.01 and

2.23 kg against V_1 (Kinnow) and V_2 (Musambi), respectively. And at T_3 fruits per plant were 1.78 and 2.61 kg on plants of V_1 (Kinnow) and V_2 (Musambi), respectively. Our results confirmed the findings of Boswell et al. (1970), Monga et al. (1995) and Nawaz et al. (2007) who found that optimum plant spacing increased the fruit yield per plant.

Conclusion

As the value of land is increasing and the available land for cultivation is decreasing, in this condition high density plantation is very important and effective as in its greatest amount of fruit bearing volume per hectare would be attained. Our preliminary results showed that T_1 (11 x 22 ft.) can prove better for satisfactory yields of the fruit. Whereas in T_2 (11 x 11 ft.) although the yield per hectare is increased but the fruits were of small sized. However, for further recommendations systematic efforts are required to study the relationship between planting densities and yield as well as quality of the fruit.

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Authors Contribution

WAD designed and supervised the overall research activities. MA, ST, NK and MI collected the data and supervised the research activities at the field level. AAK helped in the statistical analysis and article submission. MN, SA and MA helped in writing the manuscript.

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