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Study of Shade Effect of North, South, East and West Open Plants on Adjacent Internal Plants of Densely Grown Citrus Orchard

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Abstract: High-density plantations and maintaining its growth quality yield production are major concerns in citrus during current years in Pakistan. Close plantations in citrus plants produces complications ultimately lowering the quality produce. The research study was conducted on a seven-year-old kinnow (grafted on rough lemon) orchard irrigated through the drip irrigation system at Water Management Research Farm, Relana Khurd (Okara-56150) Punjab Pakistan. The orchard was planted in a rectangular layout system. The objective of the study was to evaluate the impact of North, South, East and West open plants on adjacent internal plants of a densely grown citrus orchard. Results showed a significant difference in the means of data regarding plant height, canopy area, number of fruits/plants, fruit size (diameter) and fruit yield per plant at four corners of the orchard. The southwest corner showed the maximum number of fruits at 60.75, the southeast corner 47.5, the northwest corner at 72.5, while the northeast corner expressed the minimum number of fruits at 38.75. The southwest corner showed the maximum average yield per plant 11.02 Kg, the southeast corner had an average 7.22 Kg yield per plant, the northwest corner 9.23 Kg, while the northeast corner expressed the minimum number of fruits 5.89 yield per plant.

Key words: Kinnow · High Density · Orchard Corners · Shade · Abiotic Factors

INTRODUCTION

Citrus is one of the main fruit trees in tropical and subtropical areas of the world [1, 2]. In Pakistan, 'Kinnow' mandarin is the leading citrus cultivar ranked first in terms of production and export [3]. High-density plantation in citrus is crucial and effective in this situation as it would produce the most fruit per hectare while the quantity of land accessible for cultivation is decreasing and the value of land is rising [4]. There is a need to introduce citrus plantations in high-density plantation culture [5]. It is the leading fruit of Pakistan with respect to area and production. The total area of citrus under cultivation in Pakistan is about 154, 775 hectares with a total annual production of 2, 599, 689 MMT. Regarding provincial levels, Punjab has 143, 582 hectares with an annual production of 2, 526, 898 MMT. Citrus was cultivated on 5691 ha in Sindh 33, 555 tons of annual production. Khyber Pakhtunkhwa (KP) produced 29, 236 MMT on 3722 hectares. The least production was found in Baluchistan with 10, 000 MMT on 1780 ha. During 2020-21, Pakistan exported 3, 710 thousand tons of kinnow, mainly to Afghanistan, Kuwait, Russian Federation and UAE [6].

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Various external factors effects oranges [7]. One of the previous studies proved that in subtropical citrus growing areas, high midday temperatures can cause excessively high leaf temperatures and significant leaf-to-air vapor pressure differences in sun-exposed leaves. Heat stress can lower fruit yield, quality and net CO_2 assimilation, as well as development. Average midday and VPD were decreased by 50% shade screening. In comparison to untreated trees over the course of the season, this improved AC, stomatal conductance (gs) and leaf water use efficiency, but decreased the internal concentration of CO_2 (Ci) in the mesophyll. However, leaf transpiration was not significantly impacted by darkness. Heat stress increased non-stomatal limitations to AC that were larger than stomatal limitations in the mesophyll of sunlit leaves. A shade treatment decreased leaf carbohydrates but had no impact on the height or volume of the tree canopy [8].

It has been already established that shading is regarded as a typical agricultural technique and it has lately been used in several commercial fruit orchards. Citrus trees benefit from this practice in several ways, especially in arid and semi-arid regions where it affects the microclimate of the orchard by lowering the high temperatures, light intensity, solar radiation, etc [9].

In arid and semi-arid regions, sustain citriculture encounters a variety of environmental challenges like rising temperatures, increased solar radiation and warm nights during the induction of flower buds. An interim answer to keep citrus trees growing and producing under changing climatic conditions is the use of shading nets. By altering the microclimate in the area around the trees, shading methods shield plants from a variety of biotic and abiotic stresses. Many advantages of shading nets include lowering leaf temperature and light intensity, especially at noon in the summer, boosting fruit quality, increasing tree vigor and reducing physiological disorders [10].

The aim of the study was to evaluate the shade effect of north, south, east and west open plants on adjacent internal plants of a densely grown citrus orchard.

MATERIALS AND METHODS

The research was conducted (during rabi season 2022-23) on kinnow plants having T-budded on rough lemon plants years old kinnow plants at Water Management Research Farm, Relana Khurd (WMRF) (30.8782° N, 73.5954° E) (Okara) Punjab Pakistan.

25 Plants from each corner (each experimental unit) were selected among a total of 432 kinnow plants with dense tree geometry (rectangular layout system) having a plant-to-plant distance of 2.3 m and a row-to-row distance 3.7 m on an area of 1 acre. ETo Value was computed by the mini-weather station (iMetos 3.3, release-3.0.4 / Dewberry) installed at WMRF Renala Khurd. The crop water requirement was measured by the following equation

$$Crop\ Water\ Requirement\ (CWR) = ET0\ X\ KC$$

ET0 = Evapotranspiration level which depends on the month and climatic location

KC is a crop co-efficient, month and stage of the plant. Soil moisture was measured by a soil moisture meter. The water application was done when soil moisture was depleted 50% of the field capacity. Fertigation was applied through drip irrigation according to the schedule derived through Crop Watt according to the size of the canopy. The amount of water was applied up to its field capacity and according to the size of the canopy. Based on data recorded for plant height, canopy area, number of fruits/plants, fruit size (diameter) and fruit weight the results were drawn. Analysis of variance (ANOVA) and mean comparison (LSD) was done with the statistics software (Statistix Version 10) with significance at $P \leq 0.05$.

RESULTS

Regarding the number of fruits (NOF) per plant a significant ($P \leq 0.05$) variation was observed, the north-south corner showed the maximum average number of fruits (NOF) 60.75, the southeast corner had an average 47.5 NOF, the northwest corner 72.5, while the northeast corner expressed the minimum number of fruits 38.75 NOF (Fig. 1).

Data regarding stem diameter (cm) showed significant ($P \leq 0.05$) variation among means. The southwest corner showed the maximum stem diameter (40.5 cm), while the southeast corner showed the minimum value (35 cm) regarding stem diameter. The northwest corner revealed 36 cm and the northeast corner revealed a 37.5 cm stem diameter (Fig. 2). A significant ($P \leq 0.05$) difference was observed in the means of plant height in different corners of the orchard. The southwest corner showed the maximum plant height of 270.25 cm, the southeast

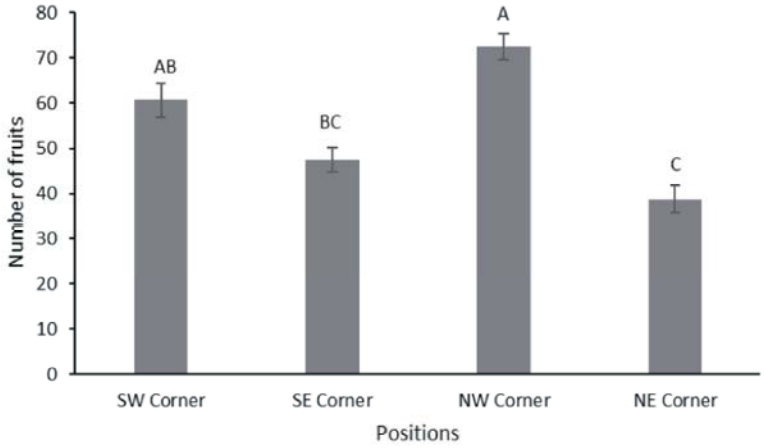

Fig. 3.1: Shade effect on the number of fruits of North, South, East and West open plants on adjacent internal plants of the densely grown citrus orchard (SE mean + is 6.01, CD at 5% is 13.60)

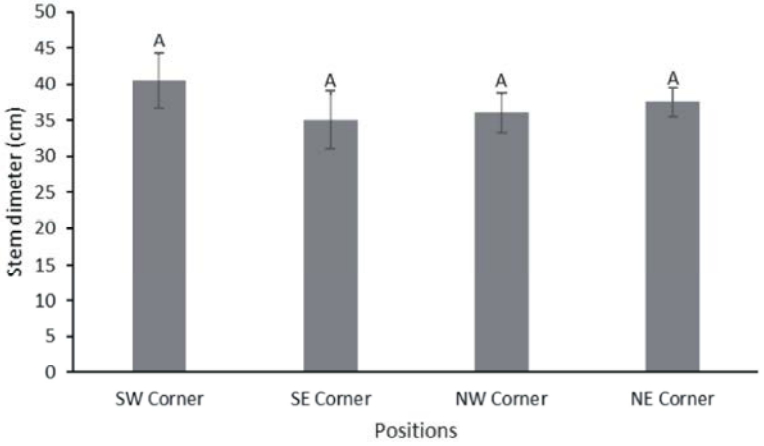

Fig. 3.2: Shade effect on the stem diameter of North, South, East and West open plants on adjacent internal plants of the densely grown citrus orchard (SE mean + is 11.65, CD at 5% is 26.35)

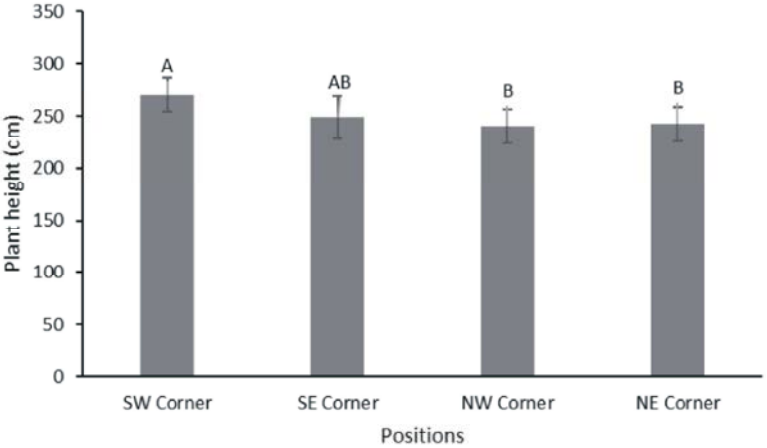

Fig. 3.3: Shade effect on the plant height of North, South, East and West open plants on adjacent internal plants of the densely grown citrus orchard (SE mean + is 12.16, CD at 5% is 27.50)

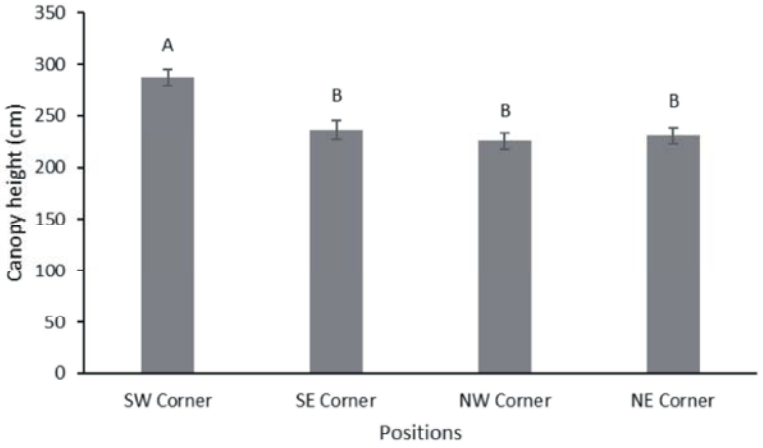

Fig. 3.4: Shade effect on the canopy height of the plants of North, South, East and West open plants on adjacent internal plants of the densely grown citrus orchard (SE mean + is 11.83, CD at 5% is 26.76)

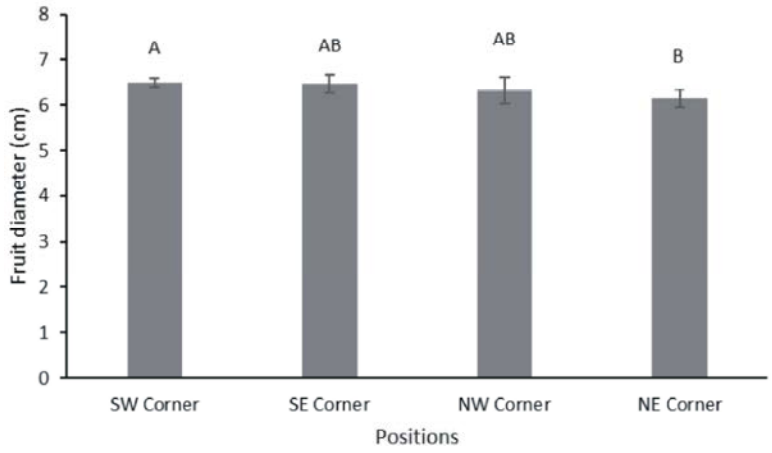

Fig. 3.5: Shade effect on the fruits diameter of North, South, East and West open plants on adjacent internal plants of the densely grown citrus orchard (SE mean + is 0.14, CD at 5% is 0.33)

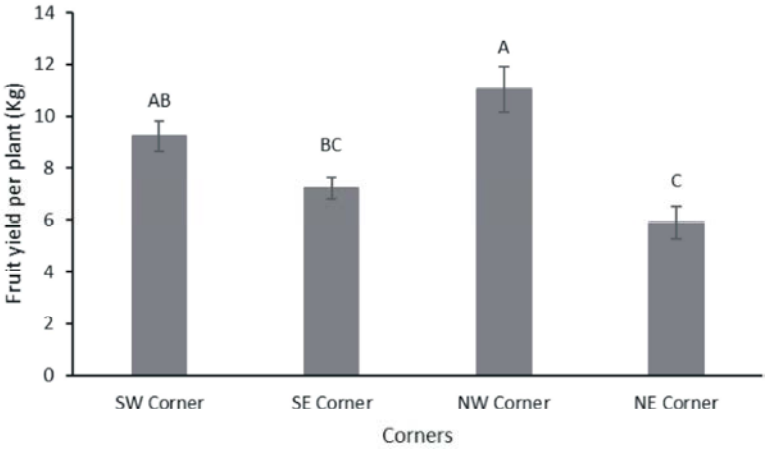

Fig. 3.6: Shade effect on the fruit yield of North, South, East and West open plants on adjacent internal plants of the densely grown citrus orchard (SE mean + is 0.9139, CD at 5% is 2.06)

corner showed 248.5 cm, the northwest corner showed 240.25 cm and the northeast corner revealed 242.5 (Fig. 3). A significant ($P \leq 0.05$) difference was seen in the canopy height of plants planted at different corners of the orchard. The southwest corner showed a maximum canopy height of 287 cm, the northeast corner showed 235.75 cm, the northwest corner was 225.25 cm and the northeast corner had a canopy height of 230.5 cm (Fig. 4).

A significant ($P \leq 0.05$) difference was seen in the average fruit diameter of plants planted at different corners of the orchard. The southwest corner revealed an average fruit diameter of 6.5 cm, the southeast corner showed 6.475 cm, the northwest corner was 6.325 cm and the northeast corner showed a 6.15 cm fruit diameter (Fig. 5). A significant ($P \leq 0.05$) difference was seen in the average yield per plant of the densely planted at different corners of the orchard. The southwest corner showed the maximum average yield per plant 11.02 Kg, the southeast corner had an average 7.22 Kg yield per plant, the northwest corner 9.23 Kg, while the northeast corner expressed a minimum 5.89 Kg yield per plant (Fig. 6).

DISCUSSION

Dogar *et al*. [4] conducted research on citrus high density and showed that musambi showed the best results as compared to Kinnow. So kinnow is more effected by high dense plantation. There are certain limitations for high-density plantation of kinnow orchards as was observed in the present results when a significant difference was seen in the average yield per plant of the densely planted at different corners of the orchard. The northwest corner showed the maximum average yield per plant, while the northeast corner expressed the minimum number of fruits yield per plant. Present results are in line with the fact that light and air circulation is restricted in various corners of the orchards. There are different challenges facing fruit production, climate change is considered one of the main threats to the sustainability of the productivity of fruit crops, due to influential fluctuations in the behavior of trees, particularly in flowering and fruit set stages, which causes negative effects on tree productivity and fruit quality [10]. It was also observed that there some plants were having more stem diameters at some corners which might be due to the fact that light and air affect assimilation pathways and nutrient uptake which leads to more growth. More sunlight on exposed plants would lead to more transpiration rate which uptake more nutrient uptake is done. So, plants have less yield which might be due to the impact of adjacent plants at some corners of the orchard. Haque and Sakimin [11] described that planting density and planting arrangement in the tropic fruit trees has a profound influence on the growth and productivity of plants. A study was conducted on the direction of solar radiation in central regions of India with the horizontal and tilted direction that produces different impacts [13]. The current results are similar to Dalal *et al*. [12] who emphasized the issue of planting density on canopy parameters, yield and water use efficiency of Kinow. The environment has always influence fruit trees production [13]. Under different environmental circumstances nutrient uptake is found differently in oranges [14].

CONCLUSION

It could be concluded that there is a profound impact on the growth and yield of kinnow plants planted at different corners in the orchard planted in dense geometry.

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