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INFLUENCE OF PLANTING DENSITIES ON PLANT GROWTH, YIELD AND QUALITY OF LITCHI CV. SHAHI

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ABSTRACT

An experiment was conducted at ICAR-NRC on Litchi, Muzaffarpur during 2013-14 comprising of 8 planting densities i.e. 2x2, 4x4, 4x6, 6x6, 8x4, 8x6, 8x8 and 10x10 m on 7thyear old plants of litchi cv. Shahi planted during 2007 with an objective to standardize optimum plant density to get higher fruit production per unit area without affecting fruit quality. Among various plant densities, moderate plant density 6x6m accommodating 256 plants/ha performed better over other densities. The highest vegetative growth in terms of canopy area (17.95m^2), plant volume (53.49 m^3) and fruit production with a tune of 18.18 kg/plant fruit yield, productivity efficiency (0.138) and fruit weight (21.51 g) was obtained in 6x6m spacing. TSS content of the fruit increased with deceasing the plant density, whereas, acidity content showed reverse trend. However, the closest spacing 2x2 m showed poor plant vigor, yield/plant and fruit quality except plant height. 6x6 m planting density showed encouraging result at the early year of fruiting and thus can be concluded that the plant population of 256 per hectare with 6x6 m spacing may be adopted for getting higher yield per unit area.

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INTRODUCTION

Litchi is one of the fascinating fruit liked by the people during the summer season (May- June) grown as cash crop and the economy of states like Bihar is dependent on it. Bihar is the leading producer of litchi which produces 234.3 thousand MT from an area of 31.48 thousand ha with a productivity of 7.4 t/ha as against the national productivity of 7.0 t/ha during 2013-14 (NHB database, 2014). As a perennial evergreen crop, it also helps in minimizing the global warming and carbon trading. The litchi fruits are commonly used for fresh consumption. The various value added products like squash, jam, jelly, dehydrated nuts and candy are also made from the fruits. It is highly specific to climatic and soil requirement and probably due to which its cultivation is restricted to the few countries in the world (Kumar *et al.*, 2014a).The success of high density planting of perennial crop depends on successful management of orchard in general and litchi in particular. High density planting system depends on maintaining a balance between vegetative growth and fruiting. If the vigor is too low, excessive fruiting results, fruit size decline, biennial bearing increases and trees fail to fill their allotted space soon enough to make the orchard profitable. If the vegetative vigor is excessive then flowering and fruiting are reduced and containment of the tree to the allotted space becomes problematic. The successful balance of vegetative vigor and fruiting results in 'calm' trees that produce heavy annual crop and require only a light annual pruning. Pruning and crop load management are the primary management practices along with fertilization and irrigation that are used to achieve a balance between vegetative growth and cropping throughout the orchards life. These management variables are affected by planting density, tree quality and tree training strategies.

Orchard having relatively lower tree number per unit area on way out and for intensive planting with smaller trees size is in vague. High density planting not only provide high production and net return during initial stage bearing, but also ensures better utilization of resources like land, labour, fertilizers, solar radiation, pesticides and floor management, which ultimately leads to higher yield (Singh *et al.*, 2012). With growing emphasis on high productivity per unit area, high density is becoming more and more popular in various crops under varied climatic conditions (Chundawat *et al.*, 1992). Planting density is the single most important factor which determines the yield of an orchard. As there is practically no scope of increasing the area under fruit crop, the only alternative left is to increase the productivity through optimum number of plant in given area. With the advancement in technologies like high density planting is a handy tool to improve the fruit productivity. HDP in litchi may be defined as the practice to accommodate 256 to 625 plants/ha and to obtained optimum yield is about 15-18 t/ha. HDP is the technique to enhance the productivity per unit area both in short duration and perennial horticultural crops. Control of shoot growth above the fruiting zone is essential to maintain light exposure to obtain quality fruits.

Traditionally, litchi trees were planted with wide spacing of 9 or 10 m x 12 m or even 12 m x 12 m, with about 70-80 trees/ha. Such plantings can have very high yields on a tree basis after 15 years, but are wasteful of land in the early years. Also, with large trees there are problems with harvesting, spraying and protection from

birds and bats. The old plantations in India, Australia and China were planted at a density of 80 to 150/ha. New orchards in Australia are planted at a closer spacing of 6 m x 8 m or 4 m x 6 m or 7 m x 3 m, equivalent to 200 to 600 trees/ha (Menzel *et al.*, 2000). In China, starting from the 1980s litchi trees were planted in closer spacing, popularly 5 m x 4 m or 6 m x 5 m, and accommodating 330-500 trees/ha. There are some extra dense orchards accommodating 1500 trees/ha (3 m x 2.5 m) (Chen and Huang, 2000).In recent years more emphasis is being given to higher production per unit area by adopting various means. One of such method is high density planting which has been well appreciated in many fruit crops. In India different planting systems (square, hedge row, double hedge, paired planting and cluster planting) as well as density (204 to 453 plants/ha) are now being investigated under the All India Coordinated Research Project in different locations. Initial results have shown that hedgerow planting is more remunerative during early fruiting years.However, there is dearth of information on response of litchi plants under HDP in India. Therefore, an experiment was initiated during 2007-08 to study the performance of litchi under various planting density with a objective to standardize the optimum plant density in order to harvest maximum yield per unit area without affecting the fruit quality.

MATERIALS AND METHODS

The present investigation was carried out at ICAR-NRC on Litchi, Muzaffarpur during 2013-14. The experimental material was considered to be uniform age of 7 year old plants of cv. Shahi planted during 2007. The experimental field was sandy loam in texture, alkaline in reaction with low to medium in fertility status. The treatment consisted of 8 planting densities i.e. 2x2, 4x4, 4x6, 6x6, 8x4, 8x6, 8x8 and 10x10 m in block plantation as 4 plants per unit and replicated thrice. Recommended package of practices adopted for management of fruit borer and other litchi pest (Kumar *et al.*, 2014b). Data pertaining to growth parameters viz. trunk cross sectional area (TCSA), canopy area, plant height and canopy volume were recorded during September month. TCSA, canopy area, plant volume and productivity efficiency were calculated as per the following formula.

Trunk cross sectional area, TCSA (cm^2) = {Trunk circumference (cm) x 0.16}^{2}x 3.143

Canopy area (m^2) = [{ Plant spread (N-S) + (E-W)/2}^{2} x 0.785]

Plant volume (m^3) = [2/3 x Plant height (m) x {Plant spread (N-S) + (E-W)/2 }^{2}

Productivity efficiency (kg/cm^2) = Yield (kg)/TCA (cm^2)

Observation on yield and yield attributes like fruit weight, size, fruit quality and yield per plant were noted during May month. The weight of the fruits was calculated on the basis of 10 representative fruits and the mean was expressed in gram. The total soluble solids (TSS) content was determined with Erma Hand Refractometer (0-32°Brix) with necessary temperature correction. The titratable acidity and ascorbic acid content of juice were estimated as per AOAC (2000).The data were subjected to statistical analysis as per the method of Gomez and Gomez (1984). Least significant of difference at 5% level was used for finding the significance of differences if any, among the treatment means.

RESULTS AND DISCUSSION

Canopy parameters

Canopy parameters viz. average plant height, trunk cross sectional area (TCSA), canopy area and canopy volume of plants were found significantly influenced by different planting densities in litchi (Table 1). The highest plant height (3.88 m) was expressed in the closest spacing (2x2m) which is closely followed by 4x4 m spacing (3.66m) whereas, both 10x10m and 8x6m spacing showed lowest plant height (3.27m). It is well established fact that under closer spacing, plant height is increased might be due to competition for light because of insufficient space. Trunk cross sectional area showed mixed trend and found maximum (148.43 cm^2) in 6x4m followed by 10x10m (143.70cm^2), 4x4m spacing (143.41cm^2) and minimum in 2x2 m spacing (79.62 cm^2). Canopy area among different spacing level found to be highest (17.95m^2) in 6x6m followed by 10x10m (17.40m^2), 6x4 m (16.94m^2) and lowest in 2x2m (8.62m^2). Canopy volume of the trees varied among different plant spacing and found relatively more canopy volume in wider spacing as compared to closer spacing. The highest canopy volume (53.49m^3) was recorded in 6x6m followed by 6x4m (50.60m^3) whereas; closer spacing (2x2m) had least canopy volume (28.57m^3). The decreasing trend observed in the canopy area with the increasing plant population might be due to the increase competition among trees for growth and development. Closer spacing plants having the tendency to grow tall with less lateral growth and plant becomes columnar in shape due to poor light interception or shading effect and plant in wider spacing had optimum space for lateral growth and hence balanced growth (Chundawat *et al.*, 1992 and Nawaz *et al.*, 2007). The least TCSA, canopy area and volume under 2x2 m spacing might be due to the competition between plants for light, water, and nutrition under closer spacing resulted less increase in basal girth and crown spread. These results are in agreement with the findings of Pandey *et al.*, 1997, Prakash *et al.*, 2012 and Pratibha *et al.*, 2013.

Yield and yield attributes

Data on flowering, fruit yield, and productivity efficiency were significantly influenced by the planting density in litchi at 7th year after planting (Table 2). Medium densities expressed better flowering percentage than higher and lower density. The highest flowering percentage (88.33%) was recorded in 4x4m spacing followed by 6x6 m spacing (85.0%) whereas, the lowest percentage (60.0%) was in 2x2m spacing. The lowest flowering percentage under ultra high density (2x2m) may be due to the overcrowding and intermingling of tertiary branches and twigs which resulted in less accumulation of carbohydrate reserves and higher source and sink competition as well as low sun light. These results are in agreement with Kumar and Rattanpal, 2010 and Lal *et al.*, 2000 observed in guava crop.

Highest fruit yield (18.18 kg/plant) was obtained in 6x6m spacing followed by 8x4m (16.45 kg/plant) and 8x6m (16.25 kg/plant) spacing. Whereas, ultra high density planting (2x2m) performed very poor yield which is significantly lower (1.53

Table 1: Effect of planting density on canopy attributes of litchi cv. Shahi (pooled)

Planting density	Plants/ha	Plant height (m)	TCSA (cm^2)	Canopy area (m^2)	Plant volume (m^3)
10x10	100	3.27	143.70	17.40	48.94
8x8	144	3.28	138.22	16.26	45.17
8x6	192	3.27	127.71	15.87	44.18
8x4	288	3.56	130.95	16.35	49.46
6x6	256	3.51	132.44	17.95	53.49
6x4	384	3.52	148.43	16.94	50.60
4x4	576	3.66	143.41	14.51	45.07
2x2	2500	3.88	79.62	8.62	28.57
CD at 5%	-	0.29	30.09	3.53	13.61

Table 2: Effect of planting density on yield attributing traits of litchi cv. Shahi (pooled)

Planting density	Flowering percentage	Yield/plant (kg)	Yield/ha (q)	Productivity efficiency (kg/cm^2 TCSA)
10x10	65.00	9.85	9.85	0.070
8x8	75.00	10.17	14.64	0.075
8x6	75.00	16.25	31.20	0.129
8x4	70.00	16.45	49.35	0.126
6x6	85.00	18.18	46.54	0.138
6x4	80.00	13.43	53.73	0.091
4x4	88.33	10.31	64.42	0.072
2x2	60.00	1.53	38.33	0.019
CD at 5%	6.24	0.82	2.81	0.021

Table 3: Effect of planting density on physico-chemical parameters of litchi fruit cv. Shahi (pooled)

Planting density	Fruit wt (g)	Pulp (%)	Seed weight	TSS (^{0}Brix)	Acidity (%)	Ascorbic acid (mg)
10x10	18.77	60.74	3.56	20.57	0.58	20.67
8x8	18.69	57.93	3.16	19.46	0.60	23.00
8x6	19.23	59.12	3.26	19.32	0.60	19.67
8x4	19.48	55.63	3.69	19.87	0.61	19.33
6x6	21.51	58.26	3.57	18.53	0.63	21.67
6x4	19.09	59.66	3.31	18.30	0.68	21.00
4x4	19.41	57.26	3.64	17.71	0.71	24.00
2x2	18.64	55.50	3.40	17.47	0.75	24.00
CD at 5%	1.92	NS	NS	1.20	0.15	NS

kg/plant) than other treatment. The highest yield under moderate plant density (6x6m) may be due to the differences in the canopy parameters particularly canopy area and plant volume which are the major fruit bearing area besides reproductive parameter like flowering percentage as evident from the present investigation. These finding are in confirmatory with the findings of Dalal *et al.*, 2013 in mandarin. Poor yield under ultra high density might be the fact that these plants had less fruiting area due to overcrowding of the branches and fruiting terminals. Once the trees have filled their allotted spaces, crowding may occur and canopies of adjacent trees begin to overlap. This may lead to excessive shading and reduction in photosynthesis by layered leaves within the tree canopy resulting in poor yields.

Yield performance on the basis of per hectare under different plant density was also calculated as per the yield obtained on per plant. The highest yield (64.42q/ha) was recorded under 4x4m spacing followed by 6x4m, 8x4m and 6x6m with their corresponding yield 53.73q/ha, 49.35q/ha and 46.54q/ha, respectively however normal spacing (10x10m) showed least yield (9.85q/ha). The higher yield per hectare under closer spacing due to higher plant population per unit area coupled with relatively more yield per plant obtained than wider and very closer spacing. The productivity efficiency of the tree was found to be maximum (0.138 kg/cm^2 TCSA) under 6x6m followed by 8x6m and 8x4m spacing distance. This may be due to the relatively higher plant yield and lower trunk cross sectional area as compared to other spacing. Similar type of results had been found by Dalal *et al.*, 2013. The lowest productivity efficiency (0.019 kg/cm^2 TCSA) obtained in 2x2m spacing. It might be due to least yield obtained under this spacing.

Physico-chemical attributes

Physico-chemical parameters of litchi fruits revealed that fruit weight, TSS and acidity content were found to be significantly influenced due to the planting densities in litchi. However, plant per unit area did not showed any significant response on pulp recovery, seed weight and ascorbic acid content of the fruit (Table 3). The highest fruit weight (21.51g) was recorded in 6x6m spacing and lowest (18.64g) in 2x2m spacing. Pulp recovery was ranged from 55.50 to 60.74 % in planting density 2x2m to 10x10m spacing. Seed weight ranged from 3.16 to 3.69g in 8x8m and 8x4m spacing. TSS content of the fruit increased with deceasing the plant density, whereas,

acidity content showed reverse trend. The highest TSS (20.57 °Brix) was noted in 10x10m spacing which was at par with 8x4m (19.87 °Brix) and 8x8m (19.46 °Brix) and lowest in 2x2m (17.47 °Brix) and 4x4m (17.71 °Brix). The acidity varied from 0.58 to 0.75% in 10x10m and 2x2m spacing. Ascorbic acid content ranged from 19.33 to 24.0mg in 8x4m and both in 2x2m and 4x4m spacing. The highest TSS and lowest acidity under wider spacing may be due to better light penetration which increases more photosynthetic activities and resulted into conversion of higher photosynthate which ultimately improve the fruit quality.

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