Studies On Different Planting System Cum High Density Planting In Litchi Cv. Bombai For Plant Vigour, Fruit Yield And Quality Under New Alluvial Zone Of West Bengal

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Abstract
A field experiment was carried out at Horticultural Research Station, Mondouri, BCKV, West Bengal during the year 2014 to 2017 to study the effect of different planting system cum high density planting in litchi cv. Bombai for plant physico-chemical properties under new alluvial zone of West Bengal. The experiment was laid out in RBD consisting of five treatments viz. Square system, Cluster planting, Paired row, Single hedge row and Double hedge row system with four replications on 12 years old healthy plants. Different planting system cum high density planting significantly influenced the plant characters of litchi. Among the physical characters, maximum plant height (5.95 m) was recorded from double hedge row planting followed by single hedge row while the spread of plant and trunk girth was found maximum in square system. Chlorophyll content of leaf (10.43 mg g^{-1}), number of fruit set per panicle and fruit retention per panicle was found maximum in square system of planting. The maximum yield (12.87 t/ha) was recorded in double hedge row system of planting while the minimum (9.01 t/ha) from square system. The total soluble solids (17.08 ^{0}brix), total sugar content, ascorbic acid and anthocyanin content (35.51 mg/100g) of fruits was found maximum in square system of planting while the minimum in double hedge row system. Finally, it can be concluded that double hedge row planting system was effective in obtaining maximum yield per hectare, while square system of planting was effective in improving the physico-chemical properties of fruits.

Keywords: *Litchi, Planting system, High Density Planting, Vigour, Yield, Quality*

1. INTRODUCTION

Litchi (*Litchi chinensis* Sonn.), an indigenous crop of South-East Asia, is an important subtropical evergreen fruit tree belonging to the family Sapindaceae, which is known for its sweet, juicy aril and aromatic flavor that dominates domestic market as 'queen of fruits' (Mishra et al., 2016). The fruit is very succulent and rich in vitamins and minerals. It is well adapted to the areas of cool dry winters and warm wet summers, usually likes low elevations but can be grown up to an altitude of 800 m above mean sea level (Priyadarshi et al., 2018). It is native of south china and reached India by the end of 17th century due to unique temperature and climatic requirements, it is widely distributed in the tropics and warm subtropics of the world (Pandey and Sharma, 1989). India ranks 2nd in the world from the production point of view after China with cultivated area expansion of 30% in the last 15 years, it occupies about 92 thousand ha of land with production of 600 thousand mt and productivity of 6 mt ha^{-1} (Anonymous, 2018). Litchi being exacting in climatic requirement is confined to a few states viz. Bihar, West Bengal, Tripura, Uttar Pradesh, Orissa, Assam, Uttarakhand, Punjab, Karnataka, Himachal Pradesh and Haryana with leading 44.2 percent of production recorded in Bihar. West Bengal with 15.5 percent occupies the second position in litchi production having 76.8 thousand tonnes production from an area of 9.4 thousand hectares (Nath et al., 2018). The main litchi growing districts of West Bengal are Murshidabad, Malda, Nadia, 24-Parganas, Hoogly and some parts of Howrah and Medinipur. Low and irregular bearing is a hurdle in successful cultivation of litchi which is preventing litchi from becoming the major crop of subtropical region so far (Stern et al., 2000; Pandey and Sharma, 1989). Litchi has been identified as one of the potential fruit for export in India but the yield from the litchi orchards is often low and variable (Mandal et al., 2017). Bombai, the commercial cultivar of West Bengal is clearly alternate bearing, particularly when the trees are older than 10-12 years (Ghosh et al., 1986). The normal planting distance in litchi is 10m apart and such orchards take about 15-20 years to provide economic returns depending upon the cultivar and cultural practices.

There has been a massive increase in the region and output of litchi in the last 50 years, but productivity has remained nearly constant, which is a major cause for concern for all of us. As land, water, and other natural resources become more limited, there is every possibility of increasing productivity in litchi through high density plantation, canopy management, and precision production tools for horticulture in days to come. Litchi is a fascinating fruit that is common among people during the summer months (May-June) and is grown as a cash crop. High density orchard appears to be the most appropriate solution to overcome low productivity and the long gestation period for early return and export of litchi. High planting density is a technique that has been widely used in fruit orchards worldwide to increase earliness to improve handling and cultural practices and to reduce costs without sacrificing fruit quality (Oosthuyse, 2009). It provides earlier output and return per unit area, reduces juvenility, and allocates resources efficiently. High density orchard has also helped in attaining significant increases in yields of fruit crops like Mango (Nath et al., 2007; Gaikwad et al., 2017), Guava (Mahajan et al., 2005; Ravishankar et al., 2008), Aonla (Singh et al., 2011) and Pear (Wagenmakers, 1989). Under sub- tropical condition climatic conditions, litchi trees tend to be precocious. Five to six year old trees can carry a good crop relative to their small size (Goren and Gazit, 1993). Information regarding high density orchard in litchi with the commercial cv. Bombai under new alluvial zone of West Bengal is lacking. Thus high density planting in litchi with different planting system were evaluated with different plant populations to find out the best plant population for cv. Bombai which would be most economically viable for the growers of new alluvial zone of West Bengal for higher productivity per unit area and quality fruit production.

2. MATERIALS AND METHODS

2.1. Experimental site

The present investigation on planting system cum HDP was carried out at Horticultural Research Station, Mondouri of Bidhan Chandra Krishi Viswavidyalaya Nadia, West Bengal, India located approximately at (23.57°N, 89°E and 9.75 m above mean sea level) for 3 consecutive years during September 2014 to July 2017. The climate of the region is humid sub-tropical with hot-humid summers and cool winters. The mean annual rainfall is 1,750 mm, out of which 80-90% is normally received from June to September. Soil at the experiment site was alluvial in nature and sandy loam in texture (sand 64.8%, silt 10.4%, and clay 24.8%) with a pH of 6.51 and contained organic carbon of 0.27%, available nitrogen 177.71 kg ha^{-1}, phosphorus 28.67 kg ha^{-1} and potassium 195.63 kg ha^{-1}. Scheduled agronomic management practices including manuring, irrigation, weeding, spraying for disease pest management and fertilization was followed as per recommended.

2.2. Experimental design and crop husbandry

Litchi cv. Bombai was planted under five planting systems, viz., T_1 Square syatem (100 trees ha^{-1}) spaced at 10m x 10m apart, T_2 Cluster planting (178 trees ha^{-1}) at spacing 5m x 5m in one of the 4 clusters and 10m between each cluster, T_3 Paired row planting (133 trees ha^{-1}) at spacing of 5m x 10m in one of the pairs and 10m between the pairs, T_4 Single hedge row (167 trees ha^{-1}) at spacing of 5m x 10m and T_5 Double hedge row (222 trees ha^{-1}) at spacing of 5m x 5m in one hedge row and 10 m between two hedges laid out in Randomized Block Design using DMRT with four replication per treatment. Each experimental plot was measured 30 m x 30 m (900 m^2). In each plot number of plants varied according to planting system, as in square system 9 plants $plot^{-1}$, cluster planting 16 plants $plot^{-1}$, paired planting 12 plants $plot^{-1}$, single hedge row 15 plants $plot^{-1}$, double hedge row 20 plants $plot^{-1}$ and were accommodated. Final observations were recorded from twelve year old healthy, bearing uniform growth, vigour air layered litchi trees cv. Bombai was selected for the present evaluation from 2014 to 2017. All the trees were maintained under uniform cultural practices during the entire course of investigation. Annual shoot pruning was performed every year as standard practice to maintain tree shape and productivity.

2.3. Methods of data collection

The physico-chemical analysis was made following all standard methods as described by Ranganna (2003). The plant height was measured from the base of the trunk to its top with the help of measuring tape attached with a bamboo pole and expressed in metre (m). Plant spread of the crown in the north-south and east-west directions were measured with the help of measuring tape and expressed in meter (m). Girth of plant was measured at 1feet above from the ground level with the help of measuring tape and expressed in centimetre (cm). The fruit drop data were also calculated on the basis of initial and ultimate retention of fruits at harvest. It was recorded by subtracting the number of fruits at harvest from the number of initial fruit set and expressed in percentage. The fruit set $panicle^{-1}$ was calculated manually by taking average of 20 panicles, 5 each from 4 directions, from each tree and replicated trees were selected and tagged just after fruit setting. Leaf chlorophyll content per unit quantity of fresh leaf tissue was measured following the procedure proposed by Amon (1949). It was calculated by the absorbance of the supernatant, read at 645 and 663 nm wavelengths under spectrophotometer (Systronics - 105 make) against a blank containing 80% acetone only. Content of total chlorophyll mg g^{-1} green leaf were estimated using the following formulae:

$$\text{mg of total chlorophyll/g of fresh tissue} = [(20.2 \times A_{645}) - (8.02 \times A_{663})] \times \frac{V}{1000 \times W}$$

The best yield indicator in fruit crops i.e. fruit retention was measured by the formula given by Sau et al., 2016.

Fruit retention % = No. of retained fruits (at harvest) ÷ No. of settled fruits initially × 100. Observations of fruit physical parameters like fruit size (length and diameter) were done with the help of Vernier Calipers. Fruit weight, Pulp and aril weight with the help of digital weighing balance was based on random ten fruit samples. The average number of fruits panicle^{-1}, number of panicle m^{-2} of canopy area were recorded and multiplied by the average fruit weight for recording the yield plant^{-1}. The yield for each treatment was estimated in kg plant^{-1} by multiplying the weight of fruit and yield plant^{-1}.

The biochemical parameters were determined from the juice extracted from 10 fruit sample for each treatment. The Total Soluble Solid (TSS) was estimated using digital refractometer (ATAGO, RX 5000, Tokyo, Japan) and was expressed as °Brix. Titratable acidity was determined by titrating 5 ml of juice against 0.1 N NaOH and expressed as percentage (Anonymous, 2000). The ascorbic acid (Vitamin C in mg 100 g^{-1}) content of fruit was estimated by using 2, 6-dichlorophenolindophenol dye titration method (Casanas et al., 2002). Total sugar (%), reducing sugar (%) and non-reducing sugar (%) were determined as per the guidelines of AOAC (2000). Anthocyanin content of fruit peel at harvest was estimated by standard procedure as described by Rangana (2003) and was expressed as mg 100 g^{-1} of peel.

3. RESULTS AND DISCUSSION

3.1 Effect of different planting system cum HDP on physical growth parameters and yield of litchi

Data on effect of different planting system cum HDP on different physical parameters of litchi plant cv. Bombai has been presented in Table 1. The different planting system significantly influenced the different physical growth parameters and yield of litchi plant cv. Bombai by increasing the plant height, canopy spread in both the direction (N-S; E-W), girth of trunk, chlorophyll content (mg g^{-1}) green leaf, fruit set panicle^{-1}, fruit retention panicle^{-1}, fruit drop percentage and yield (t/ ha) as presented in Table 1. Polled data of two years suggested that among the different planting system maximum plant height 5.95 m in T_5 double hedge row system followed by 5.65 m in T_4 single hedge row planting while the minimum plant height 5.25 m in T_1 square system. Like plant height, canopy spread in both the direction, girth of trunk, chlorophyll content, fruit set, fruit retention and yield was also affected by different planting system sum HDP. From the pooled analysis, it was found that the canopy spread in the North-South direction showed a maximum of 7.01 m in T_1 square system while the minimum 6.50 m was obtained from T_5 double hedge row system while polled data for canopy spread in East-West direction showed that the maximum spread 6.94 m in T_1 (square system) which was followed by 6.84 cm in T_3 paired row planting, while the minimum 6.14 m in T_5 double hedge row. A perusal of pooled data regarding girth of trunk in litchi showed a maximum plant girth 71.83 cm recorded from T_1 square system followed by 62.66 cm in T_2 cluster planting while the minimum girth 53.83 cm was observed from double hedge row plants. Pooled data for leaf chlorophyll content mg g^{-1} of fresh leaf showed that the maximum 10.43 mg g^{-1} was recorded from T_1 square planting followed by 9.57mg g^{-1} in T_3 paired row planting while the minimum 8.92 mg g^{-1} in T_2 cluster planting. Perusal of pooled data regarding fruit set panicle^{-1} for two years also revealed that the maximum number of fruit set panicle^{-1} 26.13 was observed in T_1 square system followed by 25.25 in T_3 paired row planting while the least fruit set panicle^{-1} 19.13 was found in T_2 cluster planting system. Pooled data for fruit retention panicle^{-1} of litchi plant also showed similar trends with the maximum 16.56 value was observed from square system, while the minimum number 12.88 was found in paired row system of planting as well as in single hedge row system. Regarding fruit drop percentage pooled analysis of data from two years also showed the maximum fruit drop 58.33% from T_1 square system followed by 54.33 % in T_3 paired planting, while the lowest fruit drop 43.83 % from T_5 double hedge row system. Perusal of pooled data for two years with regards to yield in tonne ha^{-1} showed that the maximum yield 12.87 tonne ha^{-1} was obtained from T_5 double hedge row system of planting followed by 11.75 tonne ha^{-1} from T_4 single hedge row system while the minimum yield 9.01 tonne ha^{-1} was obtained from T_1 square system of planting.

The result of the experiment revealed that different planting system cum high density planting showed varied results with respect to the vegetative growth, yield and qualitative characters of litchi cv. Bombai. Among the different treatments under study, it was found that square system of planting registered maximum plant growth compared to different high density planting systems. Significantly maximum stem girth, canopy spread in both directions and chlorophyll content in green leaf was recorded with square system of planting while minimum value for these parameters and maximum plant height were observed from double hedge row system of planting. It was well established fact that under closer spacing, plant height is increased might be due to competition for light because of insufficient space as observed by Pandey et al., (2015). 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. Similar results were obtained by Rai et al., (2002) in Shahi and China cultivar of litchi, (Chundawat et al., 1992 and Nawaz et al., 2007). The reduction in other vegetative plant growth characters in litchi trees grown under high density planting systems might be due to the competition between plants for light, water, and nutrition under closer spacing resulting less increase in basal girth and crown spread as studied by Prakash et al., (2012); Pratibha and Goswami, (2013); Policarpo et al., (2006); Carlos et al., (2012); Singh et al., (2012) and Nath et al., (2007). These findings had also been supported by earlier studies of litchi by Goren and Gazit (1993); Menzel et al., (2000) along with other fruit crops by various workers viz., pear (Policarpo et al., 2006), mango (Nath et al., 2007, Carlos et al., 2012), apple (Pramanick et al., 2012) and guava (Singh et al., 2007). In the present study, chlorophyll content of leaf varied

significantly and square system mentioned maximum value, this might be attributed to higher photosynthetically active radiation values and high chlorophyll content in square system compared to other system. The present results are in congruence with the findings of Awasthi et al., (2003) in peach, Balasimha and Yadukumar, (1993) in cashewnut.

3.2 Effect of different planting system cum HDP on fruit and yield attributes of litchi cv. Bombai

Data on the effect of different planting system cum HDP on different yield attributes of mature litchi fruits cv. Bombai has been presented in Table 2. A perusal of data from Table 2 clearly indicated that different planting system cum HDP significantly influenced the physicochemical composition of mature litchi fruit in terms of fruit weight, fruit length, fruit breadth, aril weight, peel weight, peel thickness, seed weight and aril: seed ratio. Pooled analysis of two years regarding fruit weight data clearly suggested that statistically significant variation was observed in litchi plants. From the pooled analysis, it was evident that T_1 square system have the maximum fruit weight 25.82 g followed by 23.42 g in T_3 paired row planting while the minimum 22.44 g was obtained from T_5 (Double hedge row system). A graphical comparison of both year data between fruit weight with aril weight of fruits as affected due to different planting system cum HDP has been presented in Fig. 1. Statistically significant difference among fruit length were also observed due to different planting system. Perusal of data in Table 2 showed maximum average fruit length 4.29 cm from T_1 (square system) followed by 3.88 cm in T_2 cluster planting, while the minimum fruit length 3.44 cm was found in double hedge row. Like fruit length, breadth of fruit was also significantly influenced by the different planting system cum HDP where the pooled analysis showed maximum average fruit breadth (3.66 cm) from T_1 square system of planting while the least fruit breadth 2.85 cm from T_5 (Double hedge row system). From pooled analysis of data it was evident that square system of planting have the maximum aril weight (17.83 g) followed by 16.72 g in single hedge row planting while the minimum aril weight 14.94 g was obtained from double hedge row system. The peel weight of fruit was also found statistically significant in pooled analysis of data with the maximum peel weight of fruits 4.36 g from square system, while the lowest value 3.51 g was found in double hedge row system. Pooled analysis of data showed that the maximum peel thickness of fruit 1.69 mm from T_1 (square system) plants while the minimum 1.36 mm in T_5 (double hedge row). Statistically significant variation on seed weight was also observed with different planting system cum high density planting and from pooled analysis it was observed that T_3 paired row system plants have highest seed weight 4.02 g while the lowest seed weight 3.05 g was obtained from single hedge row system T_4 plants.

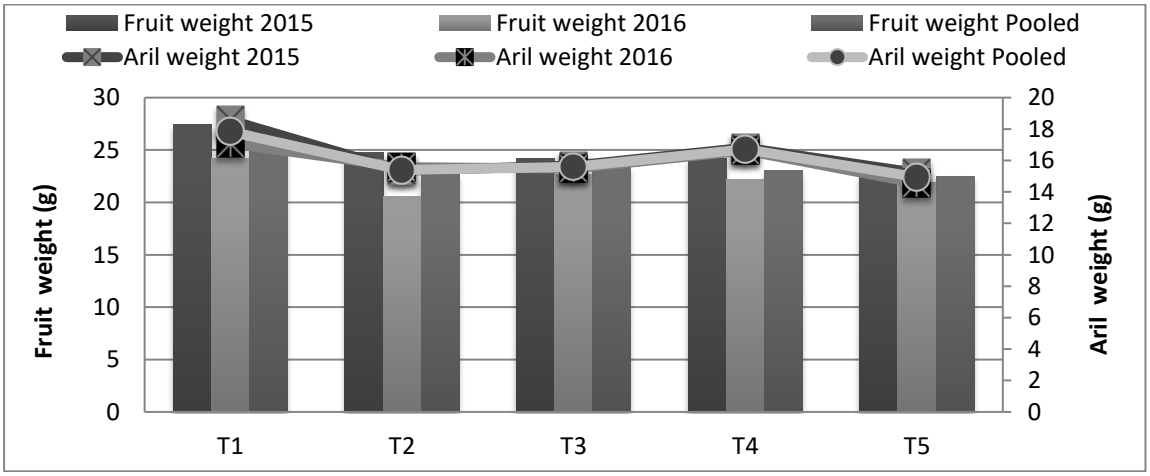

Fig. 1. Effect of different planting system cum HDP on fruit weight (g) with aril weight (g) of litchi fruit

Table 1. Effect of different planting system cum HDP on plant characters and yield of litchi cv. Bombai

Treatments	Plant height (m)	Plant spread N-S (m)	Plant spread E-W (m)	Girth of trunk (cm)	Chlorophyll content (mg g^{-1}) green leaf	No. of fruit set $panicle^{-1}$	No. of fruit retention $panicle^{-1}$	Fruit drop (%)	Yield (t/ ha)
T_1 Square System	5.25 a	7.01 b	6.94 c	71.83 d	10.43 c	26.13 b	16.56 b	58.33 d	9.01 a
T_2 Cluster planting	5.48 ab	6.68 ab	6.51 b	62.66 c	8.92 a	19.13 a	14.19 a	49.00 b	10.27 a
T_3 Paired row planting	5.56 ab	6.66 ab	6.84 c	59.58 bc	9.57 b	25.25 b	12.88 a	54.33 c	9.48 a
T_4 Single hedge row	5.65 bc	6.71 ab	6.53 b	56.16 ab	9.22 ab	24.75 b	12.88 a	49.66 b	11.75 b
T_5 Double hedge row	5.95 c	6.50 a	6.14 a	53.83 a	8.97 a	24.38 b	14.75 ab	43.83 a	12.87 b
SEm (±)	0.11	0.15	0.09	1.60	0.13	0.74	0.76	1.16	0.44
DMRT (P=0.05)	S	S	S	S	S	S	S	S	S

Table 2. Effect of different planting system cum HDP on fruit and yield parameters of litchi cv. Bombai

Treatments	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Aril weight (g)	Peel weight (g)	Peel thickness (mm)	Seed weight (g)
T_1 Square System	25.82 b	4.29 c	3.66 c	17.83 c	4.36 b	1.69	3.89 b
T_2 Cluster planting	22.68 a	3.88 b	3.46 bc	15.39 a	4.26 b	1.62	3.86 b
T_3 Paired row planting	23.42 a	3.73 ab	3.14 ab	15.59 a	3.83 a	1.43	4.02 b
T_4 Single hedge row	23.05 a	3.81 b	3.28 b	16.72 b	3.69 a	1.65	3.05 a
T_5 Double hedge row	22.44 a	3.44 a	2.85 a	14.94 a	3.51 a	1.36	3.21 a
SEm (±)	0.46	0.12	0.12	0.25	0.13	0.12	0.13
DMRT (P=0.05)	S	S	S	S	S	NS	S

Data on fruit set per panicle, fruit retention per panicle and fruit yield attribute traits in the present investigation, viz., fruit weight, fruit length, diameter, aril weight, peel weight, peel thickness, seed weight and fruit drop percent were significantly influenced by different planting system. High density planting system had significant influence on fruit yield per tree and cumulative fruit yield per ha. It was found that square system showed the highest yield attribute per tree basis while the yield per hectare was higher in double hedge row system due to higher plant population per unit area coupled with relatively more yield per plant obtained than wider and very closer spacing. Such an increase in fruit yield by accommodating more number of plants per unit area has also been demonstrated by various workers in different crops, viz., aonla (Singh et al., 2011), apple (Pramanick et al., 2012), banana (Langdon et al., 2008), guava (Singh et al., 2007) and mango (Singh et al., 2012). The maximum fruit set was recorded in square system of planting and minimum in hedge row system of planting. This may be due to various internal causes like C:N ratio internal nutritional condition, hormonal imbalances besides other soil and environmental conditions as suggested by Pandey and Sharma, (1989).

The highest fruit and yield attributes under square system 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. The smaller the area available to plants, the higher the tendency to decrease the number and percentage of lower shoots, and the number and yield of fruit per plant. As a consequence of the higher planting densities there was the reduction of the number and percentage of flowering shoots. These finding are in confirmatory with the findings of Pandey et al., (2015) in litchi cv. Sahi, Kumar and Rattanpal, (2010), Lal et al., (2000) in guava and Dalal et al., (2013) in mandarin. Significantly higher fruit drop percent was recorded in square system than in other high density planting system while double hedge row system recorded the minimum. Singh et al., (2012) observed similar results in high density planting systems of mango, although they recorded significantly higher fruit weight in double hedge row system of planting.

3.1 Effect of different sources of potassium on bio-chemical composition of mature litchi fruits cv. Bombai

Data on the effect of planting system cum HDP on the different biochemical compositions of mature litchi fruits cv. Bombai has been presented in Table 3. Bio-chemical compositions of fruits were also found to have statistically significant influence by the different planting system under study. The TSS value in pooled analysis of two years was statistically significant and found to be in the range 17.08 ^{0}brix to 18.54 ^{0}brix with the maximum value obtained from square system of planting in (T_1) square system while the minimum value was obtained from T_5 (double hedge row) plants. Regarding Total sugar value as evident from the pooled data in both years, the maximum total sugar percentage 16.78% was found in T_1 (square planting) followed by T_3 (paired row planting), while the minimum total sugar 14.98% was found from T_2 (cluster planting). Pooled analysis of data regarding reducing sugar content showed that the maximum value 13.27 % was found from T_2 cluster planting while the minimum reducing sugar 11.73 % was obtained from T_5 (double hedge row) system. The data pertaining to non-reducing sugar from pooled value showed maximum non-reducing sugar 4.63 % obtained from T_2 cluster planting while the minimum 2.40 % from T_4 single hedge row plants. The difference in acidity of fruits due to different planting system cum high density planting in Table 3 was found to be statistically significant and pooled data showed the maximum acidity (0.34%) from T_5 (double hedge row) plants while the minimum acidity 0.25% in T_1 (square system). Pooled data pertaining to ascorbic acid content of fruit as influenced by different planting system cum high density planting showed statistically significant variation with the maximum ascorbic acid value (43.81 mg/100g) from T_1 square system and the minimum (34.01 mg/100g) from T_5 (double hedge row) plants. Regarding, anthocyanin content of fruit as evident from pooled analysis of both years data showed maximum anthocyanin content 35.71 mg/100g from T3 (paired row planting) followed by 35.51 mg 100g^{-1} in T_1(square system) and the minimum anthocyanin (31.26 mg 100g^{-1}) was obtained from T_5 (double hedge row) system. A graphical comparison on anthocyanin content of fruit with ascorbic acid of treated fruits is presented in Fig. 2.

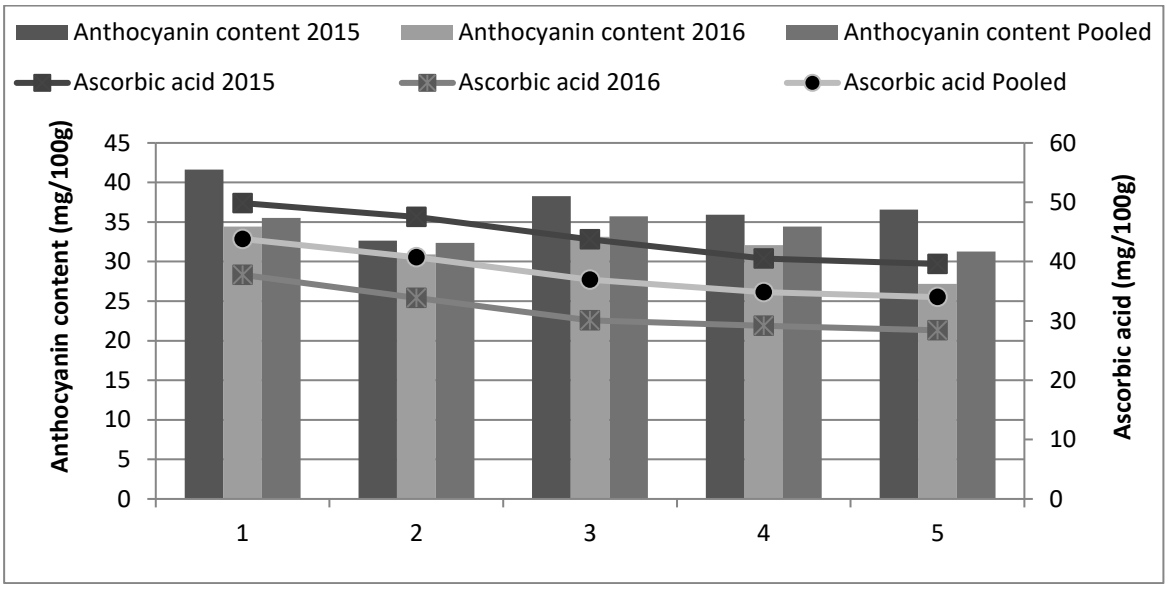

Fig. 2. Effect of different planting system cum HDP on anthocyanin content with ascorbic acid of litchi fruits cv. Bombai

Increasing plant density showed a significant variation on fruit quality attributes such as TSS, acidity and TSS: acid ratio, total sugar, reducing sugar, ascorbic acid and anthocyanin content of fruit in high density planting system of litchi. Highest total sugar content was recorded in square system followed by cluster system of planting.TSS content of the fruit increased with increasing the plant density, whereas acidity content showed reverse trend. Similar finding was observed by Mishra et al., (2016) in litchi and Carlos et al., (2012), Nath et al., (2007) in mango. Significant difference in total sugars under high density planting systems of litchi clearly reflects that fruits under wider spacing were sweeter than the higher density ones as supported by Biswas et al., (1989) in papaya cv. Ranchi. The highest TSS, lowest acidity, highest ascorbic acid and anthocyanin content in fruit 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 (Pandey et al., 2015). According to Policarpo et al., (2006), under high planting density, besides the changes in the quantity and quality of intercepted light, the partitioning of assimilates between vegetative and reproductive shoots may be responsible for the effects on fruit quality.

According to Goswami et al., (2014) the continuing decline in the availability of cultivable land, rising energy and land costs together with the mounting demand of horticultural produce, have given thrust to the concept of high density planting (HDP) of horticultural crops. High Density Planting (HDP) is one of the important methods to achieve high productivity per unit area both in short duration and perennial horticultural crops and has high relevance to the food and nutritional security of our ever increasing population (Anon., 2010).

4. CONCLUSION

On the basis of results obtained in the present investigation, improving the yield, productivity and quality of litchi fruits necessitates a number of procedures. One of the most important factors in maintaining litchi fruit yield and quality is by maintaining different density planting cum High density planting. Finally, from the present study it can be concluded that double hedge row planting system was effective in obtaining maximum yield in terms of tonnes per hectare, while square system of planting was effective in obtaining maximum individual fruit weight, fruit length, fruit breadth, aril weight, total soluble solids, total sugar, ascorbic acid and anthocyanin content of fruits. Thus in terms of production and yield T_5 (Double hedge row) was found the best while in terms of quality of individual fruit T_1 (square system) proved to be the most effective.

5. FUTURE SCOPE

The photosynthetic activities of the leaves and the amount of light penetration in the different planting system cum High density planting need to be studied further more for enhanced research purpose in increasing the yield and quality attributes of litchi fruit.

Conflict of Interest: None.

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Table 3. Effect of different planting system cum HDP on fruit and yield parameters of litchi cv. Bombai

Treatments	TSS (^{0}Brix)	Total sugar (%)	Reducing sugar (%)	Non-reducing Sugar (%)	Titratable acidity (%)	Ascorbic acid (mg/100g)	Anthocyanin content (mg/100g)
T_1 Square System	18.54 b	16.78 b	12.27 a	4.52 b	0.25 a	43.81 c	35.51 b
T_2 Cluster planting	17.23 a	14.98 a	13.27 b	4.63 b	0.33 b	40.71 bc	32.37 ab
T_3 Paired row planting	17.41 a	16.11 a	11.88 a	2.74 a	0.31 b	36.95 ab	35.71 b
T_4 Single hedge row	17.50 a	16.04 ab	12.53 ab	2.40 a	0.31 b	34.85 a	34.41 ab
T_5 Double hedge row	17.08 a	15.54 ab	11.73 a	3.65 ab	0.34 b	34.01 a	31.26 a
SEm (±)	0.34	0.51	0.27	0.43	0.02	1.33	1.47
DMRT (P=0.05)	S	S	S	S	S	S	S

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