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Effect of pruning operation and nutrition on fruit yield and quality of litchi (*Litchi chinensis*)

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ABSTRACT

A field experiment was carried out by National Research Centre on Litchi, Muzaffarpur, Bihar at farmers field for two years during 2008-09 and 2009-10 in an orchard having 18 years old litchi (*Litchi chinensis* Sonn.) plantation of cv Shahi spaced at 10 m × 10 m have shown the significant need of pruning operation and proper nutrition in commercial bearing litchi trees, which must maintain control of both tree size and fruit productivity. The types of pruning, i.e. Selective pruning to frame semicircular canopy shape and pruning to centre open the canopy with nutrition including recommended dose of fertilizers (RDF) application have been found to give significant effect on plant height, canopy volume (m^3), shoot length, shoots with bearing panicle, initial fruit set (no./panicle) and fruit yield as well as fruit weight at both treatment level and their interaction effect. Among the various treatments, selective pruning (65.65 kg/plant; 86.35 kg/plant) and nutrient application in recommended dose (60.48 kg/plant; 67.35 kg/plant) resulted in highest fruit production during both the years and their interaction effect was also found to be significant. In both the years, fruit yield increased with types of pruning system and nutrition. During the end of the experimentation, the initial and after soil test analysis for physicochemical properties showed the appreciable increase in the soil organic matter and the NPK availability status improving the soil physical properties.

Key words : Canopy volume, Fruit set, Fruit retention, Fruit yield, Nutrition, Pruning, Quality grades

Litchi (*Litchi chinensis* Sonn.) is an important commercial subtropical fruit crop having vast export potential. In general, it has been observed that the evergreen litchi tree with compact canopy leads to poor yield of inferior quality fruits due to lack of pruning operation and the problem is still aggravated due to lack of proper nutrition. Manipulation of fruit bearing through pruning and nutrition is advocated in many fruit crops for better fruit yield and quality. The frequently encountered limiting factor in the litchi fruit orchards is poor health of the trees and lack of coordination and time of phase change from vegetative to reproductive stage. According to Heinicke (1964), a layer of fruit and foliage on outside surface of the tree receives a high proportion of available light for excess of tree requirements. A second layer further (just beneath) has also adequate light and a third layer or core in the centre of the tree has insufficient light for production of quality fruits. The solution to greater productivity of quality fruits lies in eliminating the unproductive area of inadequate light exposure and early inducing more and healthy bearing/ productive shoots, which may improve the overall efficiency of the tree and this can be achieved by proper pruning technique and timely application of nutrition too. The method of pruning depends upon the growing and fruiting habit of the fruit tree and it requires to have sufficient knowledge of bearing behaviour and fruiting habit. Any kind of pruning according to its severity changes the nutritional status of the tree and consequently encourages fruit bud formation (Singh 2007). Very little works have been done on this aspect in this particular litchi fruit crops. Therefore, the present investigation was undertaken to assess the effect of pruning to shape the tree canopy and nutrition to make the balance between vegetative and reproductive phase, for increased production of quality fruits in litchi cv Shahi.

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MATERIALS AND METHODS

A field experiment was carried out by National Research Centre on Litchi, Muzaffarpur, Bihar at farmers field for two years during 2008-09 and 2009-10 in a orchard having 18 years old litchi plantation of cv Shahi spaced at 10m × 10m, been laid out and the site located at 25°54' to 26°23'latitude and 84°53' to 85°45' longitude. The experiment comprised treatments having three types of pruning operation, (Po-No pruning; P_1- pruning cuts to Centre open and P_2 – Selective pruning to shape semicircular canopy) and four levels of nutrition (Fo - No application; F_1 - Organic manure (FYM-80 kg/tree) only; F_2 - N-1000g+P_2O_5-1000g+K_2O-500g (only chemical fertilizers) and F_3- Recommended dose of fertilizers RDF(F_1+F_2) through ring method). The treatments were imposed just 15

Table 1 Vegetative growth characters of litchi as influenced by types of pruning operation and nutrient application

Treatment	Plant height (m)			Canopy volume (m^3)			No. of sprouts / branch			Shoot length (cm)		
	Initial	2009	2010	2009	2010	Increase	2009	2010	Mean	2009	2010	Mean
Pruning												
P_0	4.43	4.43	5.03	30.74	37.37	06.63	1.5	1.5	1.5	35.1	49.9	42.5
P_1	4.68	4.18	4.83	32.77	41.31	08.67	5.8	2.9	4.3	57.2	73.6	65.4
P_2	4.65	4.10	4.85	43.24	54.30	11.06	3.6	2.5	3.0	48.9	62.6	55.8
CD(P=0.05)	0.09	0.07	0.32	2.62	1.46	2.68	2.12	1.11	1.21	3.46	5.61	4.52
Nutrition												
F_0	4.70	4.33	4.90	35.21	41.97	06.94	3.8	2.1	2.9	41.3	57.5	49.4
F_1	4.43	4.36	4.83	34.06	43.30	09.23	3.2	2.4	2.8	46.2	59.7	52.9
F_2	4.53	4.10	5.06	34.13	43.69	09.39	3.8	2.7	3.2	47.6	60.9	54.3
F_3	4.67	4.23	5.30	38.93	48.33	09.56	3.6	2.0	2.8	53.2	70.1	61.7
CD(P=0.05)	0.16	0.13	0.49	3.92	2.81	5.11	NS	NS	NS	6.12	8.23	7.68
P×F CD(P=0.05)	0.31	0.24	0.78	NS	4.01	8.32	NS	NS	NS	NS	11.23	11.72

(Po – No pruning; P_1– Centre open and P_2 – Selective pruning) × (Fo – No application; F_1 – Organic manure (FYM-80 kg/tree) only; F_2 – N-1000g+P_2O_5-1000g+K_2O-600g (only chemical fertilizers) and F_3 – Recommended dose of fertilizers RDF(F_1+F_2))

days after the finish of the harvest of the previous season's fruit. The treatments were laid out in randomised block design in factorial fashion. Altogether there were twelve treatments replicated three times and two trees comprised of one treatment. The pruning operations were applied accordingly and the initial and after pruning the data for plant height were recorded along with other vegetative and reproductive parameters. Canopy volume were calculated on the basis of plant spread and canopy height using the formula :

$$2/3\pi H\ (A/2 \times B/2)$$

where H, Plant canopy height; A, canopy spread E-W, and B, canopy spread N-S; derived from the basic half ellipsoid/ spheroid volume formula. Other required observations on shoot growth, time of panicle emergence, panicle length, fruit set, fruit yield and its quality attributes were recorded. The fruit yield was also categorized into different quality grades. The quantitative characteristic data have been put to statistical analysis under factorial RBD fashion. The soil nutrient status was also analysed before and after the experimentation.

RESULTS AND DISCUSSION

Vegetative growth : Perusal of data in Table 1 for plant heights recorded for the trees at the initial stage varied from 4.43 m to 4.68 m and after imposing the treatment at the beginning found to be varied from 4.10 m to 4.43 m. The final observation in the second year the plant height varied from 4.83 m to 5.03 m. The data when compared with the initial, it was found that reduced plant height due to deep pruning cuts of the centrally selected branches in case of trees pruned for centre open was high. The plant height recorded (4.83 m to 5.30 m) significant increase with the nutrition application. Lowest increase in plant height was recorded in the treatment combination receiving no pruning and no nutrition. The treatments difference and their interaction was found to be significant for plant height. Similar results have been observed for canopy volume under different treatments. Increase in canopy volume in the second year after taking the difference have been found to be significantly higher for trees (P_2) receiving selective pruning (11.06 m^3) and it was maximum (9.56 m^3) in case of treatment having nutrition as RDF (F_3). The interaction effect for the canopy volume was also found to be significant. The appreciable increase in the canopy volume at higher side was observed in almost all the treatments having selective pruning cuts and nutrient application (Table 1). Increase in canopy volume in the trees were more towards the treatments having nutrition than pruning. Increase in canopy volume is a clear cut indication for increased portion for fruit bearing.

Number of sprouts emerged from each cut places due to pruning for centre open was more (4.3) as compared to the cases of selective pruning (3.0) and control (1.5). Number of sprouts emerged have been found to be indifferent trend with the applied nutrition. The maximum shoot length (65.4 cm) was recorded in case of pruning operation done for centre open the trees, while it increased with cases of nutrition and found significantly highest (61.7 cm) in case of treatment receiving nutrition in RDF (F_3). The interaction effect was also found to be significant. In case of selective pruning after harvest shoot length was maximum was caused due to apical dominance and faster rate of cell division and cell elongation. The number of sprouts emerging from there was though higher compared to the cases with no pruning treatments but it was lower than the stems cut made for the centre open treatment, as the thickness of the stem made with pruning cuts was more. The depth of the pruning cut to open centre, management of fertilizer just after pruning cut operations are important factor governing the chances of getting less or second undesirable flush occurring before

Table 2 Reproductive growth characters, fruit yield and fruit characters of litchi as influenced by types pruning operations and nutrient application

Treatment	Shoots with panicles (%)	Panicle length (cm)	Initial fruit set no./ panicle	Fruit retention/ panicle	Fruit yield (kg/plant)			Fruit length (mm)	Fruit width (mm)	Fruit weight (g)
					2009	2010	Mean			
Pruning										
P_0	41.5	15.8	36.5	5.25	39.32	47.02	43.17	31.80	29.05	21.61
P_1	23.0	26.8	32.5	5.33	46.20	45.60	45.90	32.27	30.20	22.20
P_2	51.2	26.5	38.8	5.98	65.65	86.35	75.85	32.47	30.35	23.17
CD(P=0.05)	3.67	2.18	1.12	NS	4.21	4.62	4.38	0.26	0.22	0.46
Nutrition										
F_0	36.7	19.1	26.7	3.93	49.40	58.13	53.57	30.70	27.63	19.29
F_1	42.3	22.5	33.3	5.80	43.79	56.94	50.36	31.67	29.83	22.84
F_2	42.3	24.0	39.3	6.00	47.89	56.20	52.04	32.43	30.60	23.19
F_3	42.0	26.5	44.3	6.33	60.48	67.35	63.91	33.90	31.40	23.97
CD(P=0.05)	NS	3.88	2.32	0.32	6.18	6.12	9.76	0.46	0.41	0.81
P × F										
CD(P=0.05)	NS	5.96	3.48	NS	11.12	7.46	NS	0.68	0.58	1.26

(Po – No pruning; P_1 – Centre open and P_2 – Selective pruning) × (Fo – No application; F_1 – Organic manure (FYM-80 kg/tree) only; F_2 – N-1000g + P_2O_5 -1000g + K_2O - 600g (only chemical fertilizers) and F_3 – Recommended dose of fertilizers RDF(F_1+F_2)

the desired time of floral stimulation. Accordingly, it has been observed that in the centre open places more of the shoots remained vegetative for the first year and again giving adequate nutrition has kept the portion of centre open remain vegetative. In case of selective pruning (more or less tip pruning) forces rapid initiation of dormant lateral sprout to form lateral shoots in a pattern determined by the location of the pruning cut (Table 1).

Reproductive growth: The number of branches/shoots which bore panicles counted on the basis of meter square frame at the sites pruning operation on the trees showed significant variation in case of treatment receiving pruning operation, which was lowest (23.0) in case of trees pruned for open centre, while the variation was found non-significant for treatments receiving nutrition. The panicle length showed non-significant variation both at individual treatment levels and also due to their interaction effect (Table 2). In litchi, stems/shoots have an apical meristem that is never fully committed to from only leaves or flowers (Batten and Mc Conchie 1995). Surrounding the resting meristem (Naphrom *et al*. 2001) is a spiraling whorl of nodes, each composed of a primordial compound leaf and a lateral meristem. At initiation, the pre-existing primordial leaves and/or lateral meristems within each node begin to develop, depending on the type of shoot, i.e. vegetative, generative or mixed. However, time of emergence of different flushes has a profound influence on the floriferousness of the shoot. The shoots having the second flush emerging during August and third during November were found to remain vegetative (Kumar 2013).

Though maximum number of fruit set per panicle at initial stage (peanut stage) was recorded in the treatment having selective pruning (38.8) and receiving recommended dose of fertilizer application (44.3) and the interaction effect was also found to be significant. Similar trend has also been observed in case of final fruit retention, where it was found significantly influenced by pruning methods and nutrition. The interaction effect was also found to be significant with respect to fruit retention per panicle. Litchi grow by recurrent flushes (Whiley *et al*. 1989, Olesan *et al.* 2002, Olesan 2005) can flower profusely but set relatively few fruit (Blumenfeld and Gazit 1974, McConchie and Batten 1991, Anila and Radha 2003). The perennial nature means that every year is depended in several ways on the previous years of life, mainly with reference to the provision of reserves of carbon and nutrients and the crop potential is determined by that status.

Fruit yield and quality: Fruit yield was recorded maximum during both the years in case of trees receiving selective pruning (65.65 kg/plant; 86.35 kg/plant) and it was also maximum (60.48 kg/plant; 67.35 kg/plant) in case of treatment receiving nutrition with RDF. The interaction effect was also found to be significant during both the years (Table 2). The mean value for fruit yield (kg/plant) has also shown that maximum fruit yield (75.85 kg/plant) was observed in the treatment having selective pruning, while it was maximum (63.91 kg/plant) in case of nutrient application in recommended dose (F_3), while it was lowest (45.60 kg/plant) for the treatment having no pruning and in case of nutrient application of only chemical fertilizers (50.36 kg/plant). The interaction effect was also significant, indicating that the conjoint use of chemical fertilizers and organic (FYM) source have beneficial effect (Table 2). This finding is well supported by many workers (Singh 2007, Rai and Nath 2001, Singh 2010), suggesting the need of proper pruning and adequate nutrition is required for increasing fruit yield with quality produce in commercial bearing litchi orchards.

The data recorded for taking account of shape and size, the characters like fruit length (mm), fruit width (mm) and

Table 3 Fruit yield and its quality characterization under different quality grades and extent of wastage in litchi as influenced by types of pruning operation and nutrient application.

Treat-ment	Fruit yield (kg/plant)	Extra Class	Class-I	Class-II	Wastage
Pruning					
P_0	43.17	14.45	26.35	43.70	14.25
P_1	45.90	18.80	35.55	35.50	10.20
P_2	75.85	22.00	38.10	32.35	08.55
Nutrition					
F_0	53.57	12.87	28.33	45.53	13.33
F_1	50.36	15.33	34.27	39.53	10.86
F_2	52.04	19.60	35.13	34.60	10.33
F_3	63.91	28.87	38.60	29.06	09.47

(Po – No pruning; P_1– Centre open and P_2 – Selective pruning) × (Fo – No application; F_1 – Organic manure (FYM-80 kg/tree) only; F_2 – N-1000 g + P_2O_5–1000 g + K_2O-600 g (only chemical fertilizers) and F_3 – Recommended dose of fertilizers RDF(F_1+F_2))

fruit weight (g), it was observed that these varied significantly at treatment levels as well as their interaction effect was also found significant. The heaviest fruit (23.17g) was found in the trees receiving selective pruning and the fruit weight value was also maximum (23.97g) recorded in case of treatments having recommended dose of fertilizer application (Table 3). The harvested fruit yield (kg/plant) when categorized for different quality grades have been found that the proportion of extra class and class I in the total yield was highest in case of selective pruning (22.00%; 38.10%), while it was observed maximum (28.87%, 38.60%) in case of treatment having nutrient application in recommended dose, while class I and class-II category of quality grades have not shown and definite trend. Though the wastage (%) was found to be decreasing with the level of treatment application, suggesting the need of pruning and nutrition for enhanced quality fruit production.

Growth responses and quality fruit yield increased due to pruning and nutrition may be attributed to altered hormonal conditions, better nutritional translocation in more numbers of new shoots and better canopy frame work. There were significant interactions between pruning treatment and application of nutrient application, which is clearly indicated through line graph (Fig 1). In discussion on competition

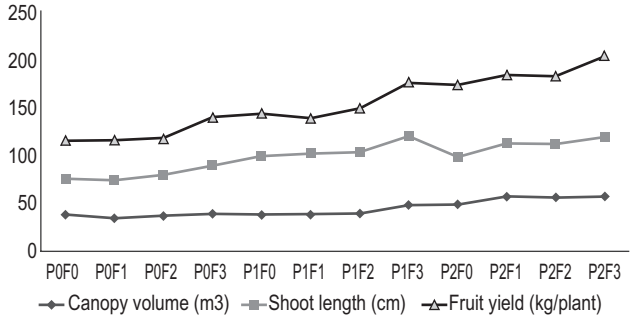

Fig. 1 Canopy volume (m3), shoot length (cm) and fruit yield (kg/plant)

between vegetative and reproductive growth observations, that fruit are dominant sinks and that new shoots, although initially a drain on nutrient resources, quickly becomes net contributors, are sometimes used to relegate the potential for vegetative growth to affect yield (Hieke *et al*. 2002a). However, while it is generally considered that reproductive sinks have a higher priority for nutrients and water than other plant parts (Wardlaw 1990, Trifilo *et al*. 2010). The results have practical implications for litchi tree management to enhance proper shoot growth during monsoon period to onset of winter season will minimise the vegetative reflushing and enhance panicle emergence (reproductive growth) and will minimize the negative effect on fruit yield and quality (Kumar 2013). In recent past, deeper pruning to shape trees, cutting branches large than 2 cm in diameter usually result in second vegetative flush occurring about three months after the first resulting no fruiting terminals. It is essential that there be only one flush of vegetative growth immediately after harvest following the synchronising pruning cuts (Davenport 2006).

The recent findings advocates pruning of litchi to facilitate healthy growth and better yield (Rai and Nath 2001). Zhang *et al*. (1999) have described the methods for pruning at top more similar to open centre window like to increase penetration of sunlight inside the canopy for better quality fruit yield. Similar to selective pruning, in Israel however, Goren and Gazit (1993) maintained the semicircular canopy stature litchi trees by topping and hedging. The main objective of selective pruning for promoting flowering has been advocated by many scientists (Galan-Sauco and Menini 1989). Selective pruning along with timely application of recommended dose of fertilizers helped in timely fostering of strong and healthy shoots giving healthy inflorescence, which lead to higher production. It also helped in better recovery of tree vigour after the fruit harvest of previous season. This particular treatment might have improved the inherent nutrient status of shoot (C:N ratio). Timely selective pruning facilitated for more reproductive growth of shoots (Zhang *et al*. 1999).

Table 4 Initial and after soil chemical properties in litchi orchard soil as influenced by types of pruning operation and nutrient application.

Treatment	EC dS/m	pH	Organic C %	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Initial	0.35	8.2	0.39	180.2	12.6	142.6
After pruning						
P_0	0.34	7.75	0.51	211.85	15.74	221.35
P_1	0.38	7.21	0.54	244.75	13.69	219.90
P_2	0.39	7.79	0.52	236.95	16.33	182.85
Nutrition						
F_0	0.39	7.85	0.43	191.20	11.41	143.00
F_1	0.36	7.65	0.53	228.53	15.80	220.53
F_2	0.37	7.35	0.55	236.53	16.55	223.60
F_3	0.39	7.46	0.56	268.47	17.27	245.00

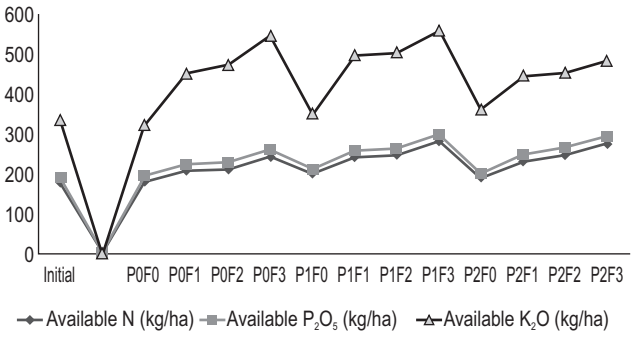

Fig 2 Available NPK nutrient status initial and final

The high fruit retention per panicle and maximum fruit yield gets support from the reports that high fruit retention in litchi can be ensured by timely treatments of plants for strong and healthy shoot production which increased flowering phase and female flower ratio and finally the fruit setting rate (Rai and Nath 2001).

Soil test analysis data on physicochemical properties of orchard surface soil under different treatments have been presented in Table 4, clearly indicated the distinct variation in soil pH as compared with initial value. Soil organic carbon content showed concomitant rise under different treatments. Available NPK were estimated in soil under tree canopy different treatments, have clearly showed the increased in status of nutrient availability in the treatments particularly receiving recommended dose of fertilizers (Fig 2). The initial and after soil nutrient analysis values when compared clearly indicated that the status of availability major nutrients increased due to the decline in pH of the rhizosphere, which ultimately improved the physical conditions and availability of nutrients. This finding finds support from the studies of Datta *et al*. (1995) and Datta and Dhiman (2001).

CONCLUSIONS

Growth responses are rapid and significant in case of litchi commercial plantation, if pruning operation and application of proper nutrition in recommended dose are made just after the harvesting of fruits of previous season is over. Significant variation in fruit yield and yield under different quality grades fruits was observed. Effect of various treatments were also found to be varied significantly for fruit length, fruit diameter and fruit weight (g). Non-selective pruning and nutrient application in recommended dose resulted in better health and fruiting performance in respect of maximum numbers of emerged shoots and fruit retention per panicle based on initial fruit set per panicle. The treatment combination having selective pruning and nutrient application in recommended dose gave significantly highest fruit yield (kg/plant) having maximum percentage under extra class on weight basis and minimum wastage as compared to other treatments. Soil health also improved with the treatment application.

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