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Integrated Soil Management Technique for Young Growing Orchards of Litchi (*Lychee chinensis*)

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A B S T R A C T

Litchi (*Litchi chinensis* Sonn) is an evergreen subtropical fruit, known for its deliciously flavoured and juicy aril, high nutrition and refreshing taste. Owing to its growing popularity, new orchards are coming up in different traditional and nontraditional area. Quality of litchi fruit is an important component for market value and is influenced by many factors including nutrient and microenvironment management. An experiment using different combination of chemical fertilizer, organic manure and bio fertilizer was conducted on young growing orchard of cultivar Sahi in order to develop technology for integrated soil management for good quality litchi production. Irrespective of treatments, increase in the yield per tree was mere indication of growing and spreading plants which is further corroborated in terms of increasing girth, height and spread of canopy every year. The highest yield was recorded under treatment having Azotobactor 250 g, half of the recommended dose of chemical fertilizers + 50 kg FYM. This was at par with the litchi yield under treatment having 5 kg vermicompost in place of *Azotobactor*. Treatment effects were not prominent during initial years of experiment. This particular treatment receiving *Azotobactor* and vermicompost also yielded better quality fruits in terms of size class, fruit weight and other bio-physical properties. Fruit yield and quality in all treatments receiving 50 Kg of FYM was at par irrespective of the choice of the biofertilizers except combinations with *Azotobactor* or vermicopost in which higher yield and better quality were realized. During the final year, stem girth in all treatment involving application of FYM in combination with different microbes (*Azospirillum, Azotobacter, Trichoderma, Pseudomonas fluencies, Aspergillus niger) were at par* but better than other treatments. Soil organic carbon increased over the year in all experiment, more in treatments having application of FYM. Soil organic carbon from the manures and fertilizer application zone in treatments having FYM were higher as compared to other which indicates effectiveness of external application of organic matter in building soil organic even in tropical/subtropical conditions of Muzaffarpur, Bihar. Though the effect of treatment was established in terms of better yield, quality and soil health improvement, it must not be interpreted as an absolute for all type and age of orchards. Low per tree yield clearly indicates that tree was yet to come to its full bearing (80-100 kg/tree).

Introduction

Litchi (*Litchi chinensis* Sonn. Sapindaceae) is known for its unique flavor and taste. It is a sub-tropical evergreen fruit crop (Singh *et al.*, 2012), successfully grown on the marginal climate of tropics and subtropics. Litchi is believed to be introduced in India in 18th century probably through north eastern part of India and its cultivation initially spread along plains adjoining Himalayan foothills. Indian litchi hits the market mainly during the first week of May and remains available till the last week of July. Some produce also comes during December-January from South India. India accounts for about one-fifth of the global litchi production. Over the years, India has recorded significant growth in area and production of litchi and presently ranks second just behind china in terms of area and production. Bihar is the leading state in India in terms of area and production of Litchi. Bihar contributes about 40% of total litchi production in India with area coverage of about 32000 ha (2014-15). It is also grown in, Tripura, West Bengal, Uttarakhand, Jharkhand, Uttar Pradesh, Assam, Punjab, Himanchal Pradesh and Haryana. Though the productivity of Litchi in India is better than some of countries including China, but this is far below the potential yield and there is scope of improvement in terms of yield as well as quality.

Insufficient and imbalanced nutrition along with water deficit have been identified as main limiting factor for poor yield and quality in almost all litchi growing countries. Further, litchi yield and quality is also subjected to year to year variation in climate and weather extremities. The litchi yield in several areas of china is low and unstable (Xu *et al.*, 2010) mainly because of unreasonable fertilization (Yao, 2009). Dynamic changes of nutrition in litchi foliar and effects of potassium–nitrogen fertilization ratio, low N and K in soil (Li *et al.*, 2011), and litchi trees with low K nutrition (Yao *et al.*, 2009) are some of the most significant reasons for low yield. The need of balanced nutrient management along with litchi cultivation practices has been reported (De Villiers, 2001). Menzel and Simpson (1987) mentions lack of a suitable nutrition program as major limitation of litchi fruit production. Three crucial stages have been suggested (FAO) for fertilizer application in Litchi; application should be prior to flowering to facilitate flower development. For 100 kg fruit, 1.5 kg urea, 0.5 kg KCl and 0.4 kg lime super phosphate are recommended at this stage. This has been contradicted by workers from India which suggest fertilizer application prior to flowering may drive vegetative flush more than flowering shoot. Small dose *i.e.* 0.5 kg urea + 0.5 kg lime super phosphate + 1.4 kg KCl for 100 kg fruit is applied after full bloom to compensate the nutrient consumed during flowering, and to improves fruit setting (Pande *et al.*, 2015). The main dose is applied prior to or just after harvest for promotion of earlier shoot and tree vigor recovery. For production of 100 kg of fruit, a combination of 1.5 kg urea + 0.5 kg KCl + 0.4 kg lime super phosphate is recommended in full grown plant on acidic soils. Recommended N:P:K for calcareous soil in Muzaffarpur district, for 100 Kg fruit from a grownup tree (>12 years) is 1KgN:0.55KgP:1KgK, all P, 75 % N and 75%K is applied just after harvest whereas rest 25% N and 25% K is applied after fruit set (Pande *et al.*, 2015).

Adding multiple sources of nutrients including organic and microbial fertilizers have been related to improved quality as well as for climate resilience. Organic component is known to improve soil water holding capacity, micro environment for microbes, improve mobility and availability of micronutrient by making chelates and also help buffer temperature fluctuation. Organic matter plays vital role especially in sandy soils, by creating adsorption surfaces and the chelating effect on various micronutrients, such as iron, zinc, copper and manganese (Sheard, 2013). Along with plant nutrition and requirement, it is also important to monitor fertilizers use efficiency, loss in different form and associated greenhouse gas emission. Attempt should be made to optimize dose and time of fertilizer application to reduce GHG emission. Rowlings *et al.,* (2013) found timing of fertilizer application critical to N_2O emission and suggested avoiding fertilizer application during the hot and moist spring/summer period that can reduce N_2O losses without compromising yield. There is indication that alternate bearing can be manipulated by soil management including N applications and that splitting N before and after harvest had the best results on building reserve levels, subsequent flowering, fruit set and yield (PNS 2017). It is suggested to apply fertilizer directly to the root zone of large trees in ditches dug 30-40 cm deep and 20-30 cm wide at two sides of the tree below the edge of the tree crown (FAO). Time, frequency and rate of K and N application in different countries are very different (Menzel *et al.,* 1992; Menzel and Simpson 1987) perhaps for varied climate, soil, litchi varieties, yield, and management practices. Though the importance of using organic, inorganic and biofertilizers in terms of yield and quality have been indicated, very limited studies are available in regards to long term soil health management for sustainable production of Litchi, especially in North Bihar. This paper deals with the experiment identifying different sources and combination of nutrient and soil health management for quality litchi production.

Materials and Methods

Study site

The experiment was conducted at research farm of ICAR-NRC for litchi, Mushahari, Muzaffarpur, (Long: 85.38ºE, Lat: 26.12ºN). The study area comes under the agro-climatic region of eastern plain sub-humid and lies in the litchi fruit export zone of Bihar. The climate is typical representative of warmer/tropical fringe of subtropical climate. Average annual rainfall is about 1180mm out of which about 90% is received during June to October in south west monsoon. Mean monthly temperature ranges from 15 to 36°C with minimum during January and maximum during May. Daily maximum temperature reaches upto 43.5 °C whereas daily minimum temperature goes below 4°C. Litchi is the main commercial horticultural crop of the area. The experiment was conducted on sandy loam calcareous, well-drained soil poor in organic matter and nutrient status. Soil pH ranges from 7.6 to 8.2 whereas EC was < 0.3 $dSm^{-1.}$ "Sahi" is the most dominant cultivars of litchi followed by cultivar "China" in this locality. Commercial cultivation is practiced with application of nutrients mainly through chemical fertilizers. Irrigation during fruiting season is a common practice in commercial orchards.

Treatments

Different combination of inorganic organic and biofertilizers were tried (Table 1). Treatment T1 which receives only major nutrients (N, P, K) in inorganic form were taken as control. Other treatments included part of chemical fertzizers, FYM and microbial culture. All the chemical fertilizers were applied during end of June, just after harvest of Litchi crop. FYM and microbial fertilizers were applied during Oct after receding of southwest monsoon. All forms of fertilizers were applied in ring of 50-60 cm wide and depth of 20 cm having outer radius just 0.5 m less than the canopy margin. In this process, different area received fertilizer during different year because of spreading canopy of young orchards.

The experiment was conducted in Randomized Block Design with three replication having 2 plants in each replication. Though the experiment was started in 2004 but application of all form of fertilizers started from 2006-07 and almost all trees come to bearing during 2009, experiment was concluded during 2015, no input was applied during 2015 however observation were taken during 2016 for residual effects of inputs.

Collection and analysis of samples

Various parameters were recorded to observe treatment effect on both plant and soil. Plant growth parameter including height, girth, canopy spread, fruit yield and quality of fruit and soil properties including micro and macro nutrient, pH, EC and organic carbon were measured during the experiment. Plant growth parameter was measured manually, Girth at predefined height (30cm) from the surface or just below the first branch by means of measuring tape, plant height by tying measuring tape with staff or iron pipe, plant spread in east-west (E-W) and north-south (N-S) direction by means of measuring tape. Fruit yield was recorded at the time of harvesting. Three random samples from harvested fruits were arranged into different class based on size of fruits. Twenty fruits from each treatment in three replicate were taken for fruit weight. TSS of 5 fruits from each treatment was determined using digital TSS meter. Soil samples were collected from fertilizer application ring just before application of fertilizer in the end of June every year. Three surface soil samples from the fertilizer application ring were composited. Plant growth parameters were measured every year during October. Long term IMD girded weather data of nearest grid was analyzed for climatic conditions.

Soil pH was measured by glass electrode and EC by electrical conductivity meter in 1:2 soil: water dilutions. Mineralizable N was determined by using alkaline $KMnO_4$ (Subbaiah and Asija, 1956), available P by Olsen method as described by Black, (1965), and available K by neutral ammonium acetate method using flame photometer. The methodology described in Methods manual Soil testing in India (Anonymous, 2011) was followed for laboratory analysis. One-way ANOVA and Duncan Multiple Range Test were performed for comparison among different treatment means (Gomez and Gomez, 1984)

Results and Discussion

Climatic condition

The long term average maximum temperature shows rainfall concentrated between 180 to 280 Julian days, representing south west monsoon season leaving other part of the year almost dry (Fig. 1). Maximum temperature starts increasing from mid of Jan and reaches maximum during May. April is the second warmest month. The two warmest months coincides with the fruiting stage of litchi. Very poor rainfall during these months render soil dry as it is exposed to high atmospheric demand. Litchi orchards in north Bihar need frequent irrigation to meet the plant and atmospheric demand as well as for thermal buffering. Low temperature exposure during Dec-Jan is crucial for flowering where as shooting temperature during April-May is one of the major limitations. The high temperature during fruit development/maturity stage is known to affect fruit setting and quality. Pollen shedding, poor fruit sets, reduced fruit size, sunburn, cracking of fruits have been related to high temperature and moisture stresses (Kumar and Nath, 2013).

Plant Growth Parameters

Plant height, stem girth and canopy spread were monitored for plant growth parameters. For younger plants, height and spread is a meaningful growth parameters along with stem girth whereas for a grownup plant height and spread no longer remains meaningful as it is subjected to modification as part of routine management. Since the observation has been taken over growing plant, parameters have got increasing trend and it is not logical to pool the data over different years.

Plant height

Plant height shows increasing trend with years across all treatments. No significant difference in height was observed except initial 2-3 years. The rate of height increase between 2010 and 2013 was found relatively higher. There was physical damage to the plant under T2 resulting less average height for couple of years, but showed compensatory tendency as it increased faster during later years (2012-2015) of the experiment. During 2007, the first year of reporting but third year of plantation the height ranges between 2.05 to 2.28 m, lower in case of T5 (Fig. 2). During last year of experiment (2015), plant height was in the range of 4.48 to 5.41m whereas during 2016 it was between 5.15 to 5.61m. Effect of treatments in terms of height was not apparent in later years of the experiment. The increasing trend continued across all treatment. It was apparent that for plant height, mere application of inorganic form of macronutrients (T1) along with residue recycling was sufficient. Though the rate of height increase was higher in T5 as it could compensate for low initial base level but it may also be due to compensatory tendency in young plant instead of treatments. There was not input applied after harvest of litchi in 2015, nevertheless growth trend continued.

Plant girth

Unlike plant height and spread, plant girth is more suitable and stable parameter for growth assessment, as it is not altered in routine training and pruning of orchards. During 2001, plant girth was in the range of 31.5 to 38.3cm. The relative growth was found compensatory in nature and by the year 2010 plant girth across all treatment was at par with each other and in the range of 37.2 to 41.8cm (Table 1). The treatment effect was noticed after 2011. During 2014, the treatment receiving FYM in various combinations with microbial culture was having relatively higher girth. The same trend with prominent difference was observed during 2016. The highest girth was recorded in T5 and T6 and lowest in T1 and T2 receiving only inorganic form of fertilizer. The significant difference during later years of experiment indicates a gestation period plant takes to respond in terms of girth against the soil management. Compensatory behavior could not be corroborated for girth, unlike to plant height. The plant girth observed during 2016 was in the range of 57 to 73.7 cm, highest in T5.

Plant spread

Plant spread is an important growth parameter as it indicates the potential fruiting area of a tree. During initial years of observation (2007), plant spread in east-west (E-W) direction was in the range of 2.65 to 3.56m, lower under treatment T5 (Table 2). There were variations across the treatments which are expected due to natural heterogeneity in perennials. The variations among treatments continued till 2011, however during 2014, E-W spread was significantly higher in all treatments receiving FYM (T3-T8) in various combinations with microbial culture or vermicompost and among these treatments, there were no significant difference. During 2016, pruning and training was performed to bring proper shape and homogeneity in different trees. The E-W spread was modified and made in the rage of 5.5–5.65 m. The increasing trend continued further.

Table.1 Treatment details of the experiment

Treatments	**Substrates Dose**
T_1	N:P:K calculated as per age (100g:50g:50g for first year, 200g,100g,100g for second year and 1000g : 500g : 500g NPK/tree for tenth years onwards (control)
T_2	T_1+ Zn (0.5%) + B (0.2%) + Mn (1%) + Ca (0.6%) as foliar spray twice (Aug. and Oct.).
T_3	½ T_1 + 50 kg FYM*
T_4	½ T_1 + 50 kg FYM* + 250g *Azospirillium*.
T_5	½ T_1 + Azotobactor (250g) + 50 kg FYM.
T_6	½ T_1 + 50 kg FYM* + 5 kg Vermi compost.
T_7	½ T_1 + 50 kg FYM* + 250 g *Pseudomonas fluorensence*.
T_8	½ T_1 + 50 kg FYM* + *Trichoderma* (250g) + *Pseudomonas* (250g).

FYM* @ 5kg for first year and 50 kg for tenth year onwards) + *Trichoderma* (250g).

Table.2 Plant girth under different treatments during different years of experiment

	Plant Girth (cm)					
Treat ments	**2007**	**2008**	**2010**	**2011**	**2014**	**2016**
T_1	31.5a	35.3a	38.4	47.3a	53.5a	57.0a
T_2	36.0ab	38.3b	41.6	53.6	54.2a	58.7a
T_3	35.0ab	36.7a	41.8	50.4	60.1bc	68.2b
T_4	38.3b	39.1b	40.6	49.6	57.4b	69.1b
T_5	35.3ab	37.3a	39.4	45.1a	59.3bc	73.7c
T_6	35.5ab	36.0a	37.8	47.1a	61.5c	72.0c
T_7	33.7a	34.3a	38.2	44.6a	59.4bc	69.0b
T_8	38.0b	39.3b	42.1	50.7	61.7c	69.2b

Table.3 East-West spread of plant during different years of the experiment

	2007	**2008**	**2010**	**2011**	**2014**	**2016***
T_1	3.25bc	3.53cd	4.08b	4.28d	5.12a	5.50
T_2	3.56c	3.75c	4.25	4.36ad	5.05a	5.54
T_3	3.06ab	3.19ab	3.89a	4.51ac	5.38	5.54
T_4	3.10b	3.4bd	4.11	4.10b	5.55	5.56
T_5	2.65a	2.95a	3.48a	4.57c	5.52	5.60
T_6	3.00ab	3.16a	3.55a	4.60c	5.48	5.64
T_7	3.10b	3.35bd	4.03	4.43a	5.51	5.65
T_8	3.1	3.5	4.03	4.61	5.9	5.57

Table.4 North-South spread of plant during different years of the experiment

	2007	2008	2010	2011	2014	2016*
T_1	3.05b	3.23b	4.08	4.68	5.93ab	5.55
T_2	3.5c	3.66c	4.25	4.28	5.83a	5.48
T_3	2.96a	3.04a	3.8a	4.53	6.20	5.54
T_4	3.13b	3.36b	4.11	4.28	6.03b	5.56
T_5	2.68a	2.95a	3.8a	4.22	6.33	5.66
T_6	3.1b	3.26b	3.75a	4.43	6.03b	5.68
T_7	3.1b	3.3b	4.03	4.63	6.20	5.65
T_8	3.21b	3.5b	4.03	4.88	6.16	5.57

Table.5 Fruit yield and average percent yield under different class during different year

	Fruit yield (kg/plant)						Fruit under different class			
Treatments	2009	2011	2013	2014	2015	2016*	EC (%)	C-I (%)	C-II (%)	Wastage (%)
T1	8.6	13.3a	15.7a	23.3a	16.4a	27.6a	26.3	38.0	20.5	15.1
T2	9.6	11.3a	16.3a	25.4a	14.3a	33.3a	24.0	34.8	26.2	13.5
T3	8.7	17.4b	23.6b	18.9d	20.4b	41.5b	25.9	32.5	29.3	12.3
T4	9.0	15.3b	23.0b	31.2b	26.4c	40.7b	28.9	32.2	26.2	12.7
T5	13.0a	17.6b	28.4c	35.3c	28.2c	48.3c	31.5	31.5	26.5	10.4
T6	14.3a	16.3b	25.6c	34.5c	28.6c	46.6c	31.0	31.1	27.4	9.7
T7	9.7	13.7a	21.6b	29.8b	25.2cd	41.7b	27.8	34.5	25.8	12.1
T8	10.6	14.6ab	19.3ab	33.4bc	21.4bd	39.4b	30.0	35.4	23.8	10.8

Table.6 Average fruit dimension, total soluble solid, of fruits under different treatments

	Fruit Length (cm)	Fruit Diameter (cm)	Fruit weight (g)	TSS (Brix)
T1	3.11	2.87	22.35	20.17
T2	3.28	3.09	22.81	20.68
T3	3.24	3.06	23.31	20.76
T4	3.24	3.00	23.79	20.37
T5	3.47	3.25	25.43	21.12
T6	3.54	3.15	25.58	19.98
T7	3.34	3.07	24.76	20.01
T8	3.29	3.07	24.03	19.95

Table.7 Soil Physicochemical parameters changes under different treatments during experimental period

	EC dS/m		pH		OC (%)		BD (g/cm3)
	2007	2016	2007	2016	2007	2016	2016
T_1	0.31	0.18	7.8	7.89	0.27bc	0.39a	1.48a
T_2	0.27	0.21	8.08	7.77	0.31d	0.40a	1.51a
T_3	0.24	0.19	8.08	7.51	0.34d	0.57	1.35
T_4	0.25	0.24	8.04	7.56	0.27bc	0.61	1.36
T_5	0.27	0.25	8.09	7.42	0.25b	0.58	1.35
T_6	0.26	0.31	8.06	7.53	0.28c	0.63	1.41
T_7	0.24	0.24	7.99	7.56	0.28c	0.59	1.39
T_8	0.25	0.24	8.08	7.48	0.22a	0.57	1.40

Table.8 Changes in plant available N, P and K under different treatments during experimental period

	Available N(kg/ha)		Available P (kg/ha)		Available K (kg/ha)	
	2007	2016	2007	2016	2007	2016
T_1	179.2	209.8	20.6	19.5	198.4	222.2
T_2	189.3	211.6	9.1	17.2	240.2	235.4
T_3	208.1	231.7	4.6	10.6	228.3	265.6
T_4	198.6	222.4	6.9	9.9	140.7	260.4
T_5	180.7	231.9	6.9	9.9	158.4	255.2
T_6	196.0	246.6	4.6	13.6	131.2	232.4
T_7	190.0	231.4	9.1	16.1	159.6	241.2
T_8	190.4	235.3	32.0	27.4	103.7	212.8

Fig.1 Long term average of daily rainfall, maximum and minimum temperature

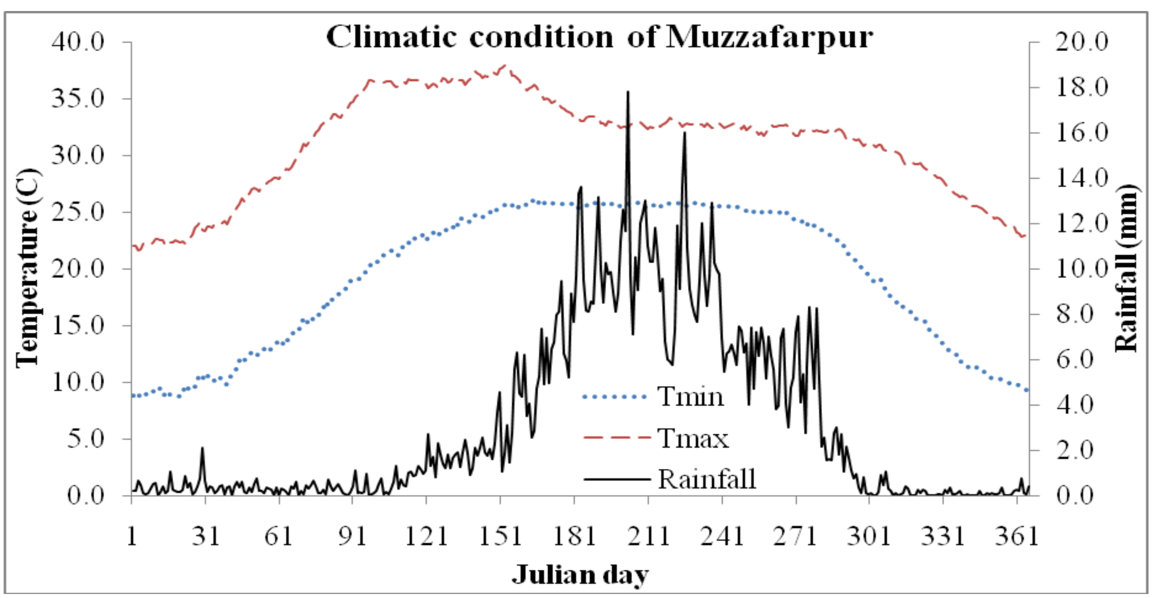
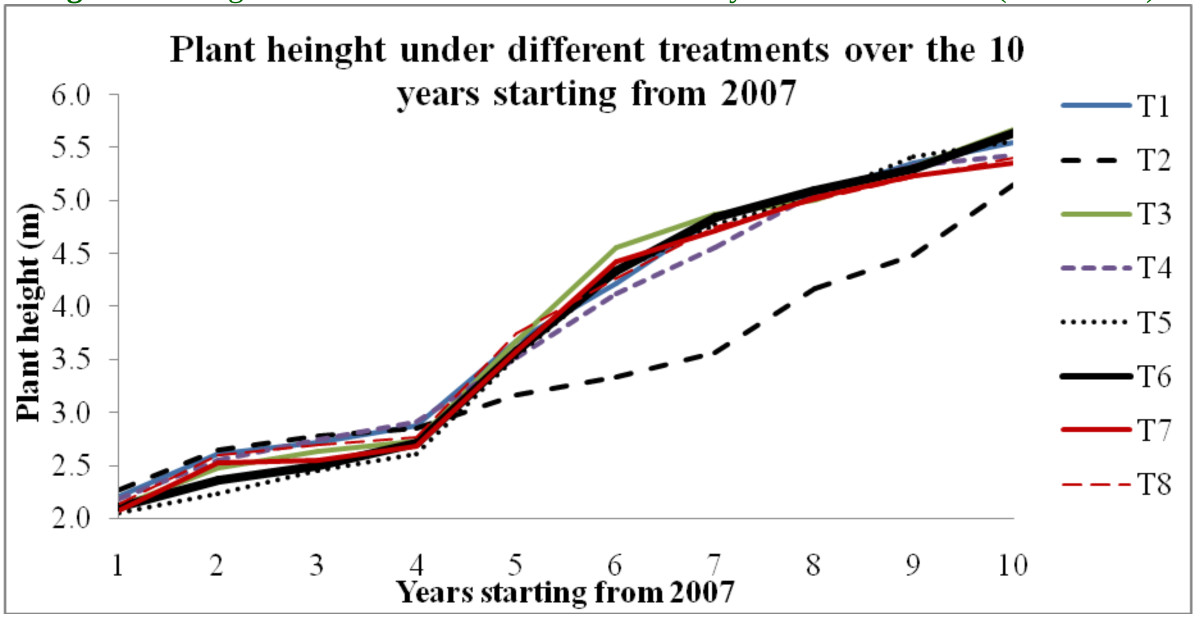


Fig.2 Plant height under different treatments over the years of observation (2007-2016)



The increasing trend in spread was also observed in north-south (N-S) direction which is common for young orchards. In the year 2007, the N-S spread was in the range of 2.68 to 3.21 meter, lowest under T5 (Table 3). There were variations across the treatments and replications during initial years of experiment. The effect of treatments and /or compensatory tendency was observed from the year 2011 onwards. There was no significant difference in N-S spread among treatments during 2011. During 2014, the N-S spread was in the range of 5.83 to 6.33m. The treatment T5 recorded highest N-S spread despite of lowest spread in first year (2007) of observation. During 2016 it was pruned to bring uniformity and proper shape. N-S spread seems to be more responsive to soil management including FYM, but further investigation is required for corroboration.

Fruit yield and quality

Fruit yield and quality was found affected by different treatments. Monitorable yield were recorded from 2009 onwards. During 2009, yield under different treatments were in the range of 8.60 to 14.3. Highest was recorded under T5 and T6. Same trend followed in later years of experiment. The effect of application of FYM in combination with different inorganic fertilizer and microbial culture/vermicompost could be seen evident as compared to only inorganic inputs (T1 and T2). Highest yield was recorded under T5 and T6 almost every year. The higher yield under T5 may be due to higher efficiency of *Azotobacter* in combination of FYM as compared to other microbial culture. The application of *Azotobacter* in combination with FYM could compensate for application of 5 kg vermicompost in T6 as yield was at par with T6 for most of the years. Despite of no application of any form of nutrients after harvest of litchi during 2015, higher yields were recorded across all treatments during 2016. The yield per tree rages between 29.6 and 48.3 kg during 2016 (Table 4). There was bumper crop of litchi in locality as well, during 2016. Relatively higher yield was recorded in all treatments receiving FYM (T3-T8) as compared to treatments receiving only inorganic form, and highest under T5, which was at par with T6. This indicates residual effect of application of inputs, more in case of organic form.

Fruit quality: treatments effect was also reflected in terms of fruit quality. Fruits samples were grouped in to three different classes based on fruit size. More fruits under extra class (EC), largest among quality group, were recorded under T5 and T6 (Table 4). The lowest wastage were also recorded in T6 (9.7%) and T5 (10.4%). Highest fruit length, diameter and weight were also recorded under T5 and T6 (Table 5). No apparent difference could be observed in total soluble solid (TSS) under different treatments.

Impact on soil health

Soil parameters at the end of experiment were compared with the initial year of observation. Electrical conductivity during 2007 was in the range of 0.24–0.3 dSm^{-1} (Table 6). There were changes in EC across the treatments but neither could it be correlated with treatment nor was it in the range of attention for management. Initial soil pH was in the range of 7.8 to 8.9 whereas during 2016 it was found in the range of 7.42 to 7.89 (Table 6). Reduction in pH was observed in all treatments, relatively more in the treatments receiving FYM. The reduction may be due to incorporation of organic matter either in form of FYM or the plant residue (leaves and roots). More reduction in treatments having FYM corroborates the role of organic matter in reducing pH in calcium rich soil. Soil was poor in organic matter as SOC was in the range of 0.22 to 0.34% during initial year of observation (2007). The SOC increased over the year and during 2016, it was in the range of 0.39 to 0.61 (Table 6). This substantial increase in SOC all across the treatment may not be only due to external application of FYM or vermicompost, though higher increase were recorded in all treatments receiving FYM (T3-T8). The increase may also be attributed to the residue incorporation in form of leaves and roots which is likely to be higher in case of good management practices. Further it is to note that sample were collected from surface only and also from the confined input application belts only.

There were increases in available NPK over the period of experiment all across the treatments. Initially N was in the range of 179.2 to 208.1 kg/ha which increased over the period of experiment and during 2016, it was found in the range of 201 to 247 kg/ha (Table 7). Relatively higher increase was recorded in the treatments receiving FYM. Available P also increased in all treatments except T1 and T8. There were high variability in available P and initially it was in the range of 4.6 to 32 kg/ha. During 2016, available P was in the range of 9.9 to 27.4 kg/ha. Substantial increase in available K was also recorded across all treatments. In-situ biomass addition (leaves and roots) external application of FYM and fertilizer may be attributed for increased N, P and K. Further, collection of sample from the confined fertilizer application ring and upscaling data on per hectare basis may also be reason of apparently high available N, P, K during 2016 (Table 8).

The integrated source of nutrients including organic and bio fertilizers has been found useful for balance supply of nutrients as well as to maintain soil health. The micronutrients often form stable organic complexes with lignin, humic and fulvic acids. The formation of soluble chelated complexes enhances the availability of the elements to plants. Besides, organic inputs create a favorable environment for beneficial soil microbes, which utilize the organic material as source of energy and often outcompete harmful microbes. Dutta *et al.,* (2010) used different organic nutrition to reduce the chemical fertilizers and found significant positive effect on yield, fruit quality and leaf mineral content. The treatment consisting 500 g N: 250 g P_2O_5: 500 g K_2O along with FYM @50 kg/tree +150 g *Azotobacter*+100 g VAM+ per tree every year showed maximum yield (98.72 kg/plant) better quality in terms of TSS, total sugars, ascorbic acid, TSS: acid ratio, fruit weight, fruit size and anthocyanin content. Only organic manure and bio fertilizers treatment though improved fruit quality but failed to match productivity level. Devi *et al.,* (2012) investigated the use of poultry manure, kraal manure, and various biofertiliser combinations (*Azotobacter, Azospirillum*, phosphorous and potassium solubilises) and found a combination of the manures, beneficial organisms and solubilises as most effective at improving soil health (microbial population) and fruit growth parameters compared to the use of manures alone. Devi *et al.,* (2014) observed application of farm yard manure + *Azotobacter* + phosphorous solubilizers + potash mobilizers result into greater fruit weight, total soluble solids and total sugar content, whereas the number of fruits and fruit yield (61.59 kg compared to 23.94 kg/tree in control) were greater with vermicompost + *Azotobacter* + phosphorous solubilizers + potash mobilizers. Application of organic source of nutrients along with biofertilizers improved soil health by increasing the microbial population in the rhizosphere. Improvement in soil microbial population and other soil characteristics by application of organic and biofertilizers have been reported (Dutta and Kundu, 2011) which also highlights the importance of integrated or organic approach of soil management. Improvement of soil organic carbon in response to application of FYM as observed in this experiment has been reported from other experiment in tropical condition (Kumar *et al.,* 2014) Rathore *et al.,* (2013) reported significant effect of use of organic nutrients to reduce the quantity of inorganic fertilizers on growth, yield and quality of litchi cv. Rose Scented. The above observations of different researchers were found in line with the observation made in this experiment.

This experiment on integrated nutrients and soil health management had specificity of age of orchards, typical soil and climate and one of the most popular cultivar (Sahi). The FYM was found effective in reducing chemical fertilizer and also boosted plant growth, fruit yield and quality. Azotobacter in combination with FYM along with 50% RDF was found effective in improving plant growth, yield and quality and could compensate for 5kg vermicompost per tree. The strong residual effect observed during last yers of experiment suggests improvement in soil environment to support litchi production to a certain extent even without any input. Improved soil organic matter and reduced pH was other prominent observation which need further corroboration in case or old orchards in which volume of residue incorporation may outdo the external application of FYM. Though the importance of integrated source of nutrients in younger orchards (5 to 12 years) have been indicated in form of better growth, fruit yield and quality, there is further need to establish integrated nutrient combination for full grown orchards in the traditional belt of Litchi for sustainable soil health management towards improving income from litchi production.

The Integrated approach including organic and bio fertilizer is also expected to increase soil buffering capacity against climate extremities thereby adding climate resilience which is crucial to sustain production and keys towards doubling farm income. This experiment helped generate integrated soil health management technology for young orchards (5 to 12 years) comprising annual application of ½ RDF + 50 Kg Farm Yard Manure (0.5 %N) + 250 g Azotobacter/ 5 kg vermicompost recommended for higher yield, good quality (in terms of fruit weight, TSS and Acidity), improved soil health in form of improved organic carbon, reduced pH and increased available nutrients in the soil.

References

Anonymous, (2011) Methods Manual, Soil Testing in India, Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India, New Delhi.

Black C A. (1965) Methods of Soil Analysis, Vol 1. American Society of Agronomy, Madison, Wisconsin, USA.

De Villiers (2001) The Cultivation of Litchi, E.A. (ed.). ARC-Institute for Tropical and Subtropical Crops. Nelspruit.

Devi, H. L., Poi, S. C., and Mitra, S. K. (2014) Organic nutrient management protocol for cultivation of 'Mombai' litchi, ISHS Acta Horticulturae 1029: IV International Symposium on Lychee, Longan and Other Sapindaceae Fruits, DOI:10.17660/ActaHortic.2014. 1029.25

Devi, H.L., Poi, S.C. and Mitra, S.K. (2012) Organic Nutrient Management Protocol for Cultivation of Litchi cv. Bombai. Proceedings of the 4th International Symposium on Lychee, Longan and other Sapindaceae Fruits, Nelspruit, South Africa.

Dutta P, Kundu S and Biswas S. (2010). Integrated nutrient management in litchi cv Bombai in new alluvial zone of West Bengal, *Indian Journal of Horticulture*, (2) 181-184

Dutta P. and Kundu, S. (2011) Effect of organic manure and biofertilizers on organic production of mango. Proceedings of the third scientific conference of ISOFAR, 1: 475-478

Gomez, K.A. and A.A. Gomez, (1984) Statistical procedures for agricultural research (2 ed.). John wiley and sons, NewYork, 680p.

Kumar G., Kurothe, R. S., Brajendra, Vishwakarm, A. K., Rao, B. K. And Pande, V. C. (2014) Effect of farmyard manure and fertilizer application on crop yield, runoff and soil erosion and soil organic carbon under rainfed pearl millet (*Pennisetum glaucum*), *Indian Journal of Agricultural Sciences* 84 (7): 816–23

Kumar, R. and Nath, V. (2013) Canopy Management in a book entitled “Climate Resilient Horticulture-Adaptation and Mitigation Strategy” edited by Singh, H. C. P., Rao, N. K. S. and Shivakumar, K. S. Springer Science & Business Media, 15-Mar-2013 - Technology & Engineering - 303 pages.

Li, G., L., Yao, L.X., Zhang, Z.Q., He, Z.H., Zhou, C.M., Huang, L.X., Guo, B., Tu, S.H. 2011. Temporal and Spatial Variation of Nutrient Fertility on Guangdong Litchi Plantation. Chinese Journal of Soil Science. 42(5), 1081-1086.

Menzel, C. M. and Simpson, D. R. (1987) Lychee nutrition: A review, Scientia Horticulturae, 31(3-4): 195-224

Menzel, C.M., Carseldine, M.L., Haydon, G.F. and Simpson, D.R. (1992) A review of existing and proposed new leaf nutrient standards for lychee. *Scientia Horticulturae*. 49, 33-53.

Pandey, S.D., Kumar, A., Patel, R.K. and Srivastava, K. (2015). Litchi Uttam krishi Kriyayen: Sthapit Bag men Masik Karyakarm (Ext. Folder No. 16). ICAR National Research Centre on Litchi, Muzaffarpur. 6p

Plant nutrition symposium (2015/2017) from soya to litchi, https://agriorbit.com/plant-nutrition-symposium-from-soya-to-litchi/

Rathore, N., Mishra, N. K., Lal, R.L., Mishra, D. S. (2013) Effect of integrated nutrient management on yield and quality of litchi cv. Rose Scented, *Pantnagar Journal of Research, 11: 369-372.*

Rowlings, D. W. Grace, P. R., Scheer, C., Kieseb, R. (2013) Influence of nitrogen fertiliser application and timing on greenhouse gas emissions from a lychee (*Litchi chinensis*) orchard in humid subtropical Australia, Agriculture, Ecosystems & Environment 179(1):168-178

Sheard A., (2013) Influence of organic matter and manures on litchi nutrition and tree health, Subtrop Quarterly Journal. http://litchisa.co.za/Vol1InfluenceOfOrganicMatter.pdf

Singh, G. Nath, V., Pandey, S. D., Roy, P. K. and Sigh, H. S. (2012), The Litchi, published by Food and Agricultural Organization of the United Nation, New Delhi, India

Xu, Y.J., Wen, J., Xiao, G.S., Zhang, M.W., Li, S.F., Wu, J.J. (2010). Comparative studies of processing characteristics of different litchi varieties. Food Science. 31(1), 33-37.

Yao, L.X. (2009). Investigation report on the application and demand of national litchi nutrient management technology. Litchi Science Technology Communications. 3, 41-54

Yao, L.X., Li, G.L., Yang, B.M., He, Z.H., Zhou, C.M., Huang, L.X., Guo, B. (2009). Nutrient accumulation properties of Guiwei and Feizixiao litchi. Litchi Science Technology Communications. 2, 52-64.

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