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Integrated nutrient management in litchi (*Litchi chinensis* Sonn.) cv. Muzaffarpur for yield and fruit quality at foothills of Arunachal Pradesh

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Abstract
The present investigation to study Integrated Nutrient Management in Litchi (*Litchi chinensis* Sonn.) cv. Muzaffarpur for yield and fruit quality was carried out in 7 years old trees of uniform size during 2017 at Fruit Research Farm, Department of Fruit Science, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh. The experiment was laid out in Randomized Block Design with 9 treatments and 3 replications. The treatments were T_1=1000 g N+500 g P+500 g K (control)., T_2=500 g N+250 g P+250 g K+ 50 kg Vermicompost., T_3=500 g N+250 g P+250 g K+100 kg FYM., T_4=500 g N+250 g P+250 g K+100 kg FYM+100 g PSM., T_5=500 g N+250 g P+250 g K+100 kg FYM+150 g Azotobacter., T_6=500g N+250 g P+250 g K+100 kg FYM+100 g VAM., T_7= 500 g N+250 g P+250 g K+ 100 kg FYM+150 g Azotobacter +100 g PSM., T_8=500 g N+250 g P+250 g K+ 100 kg FYM+150 g Azotobacter+100 g VAM., T_9=500 g N+250 g P+250 g K+100 kg FYM +150 g Azotobacter +100 g PSM+100 g VAM.
Experimental results revealed that the imposition of different treatments had a significant effect on yield and fruit quality of litchi. Maximum number of fruits per tree (1281), fruit yield (30.01 kg/tree), total sugar (26.14 %), reducing sugar (14.51 %) was observed in 500 g N+250 g P+250 g K+100 kg FYM+150 g Azotobacter+100 g PSM+100 g VAM (T_9). The control 1000 g N+500 g P+500 g K recorded maximum fruit cracking. Application of 500 g N+250 g P+250 g K+100 kg FYM+150 g Azotobacter+100 g PSM+100 g VAM (T_9) was most effective treatment with respect to yield and fruit quality of litchi in foothills of Arunachal Pradesh.

Keywords: Biofertilizers, FYM, litchi, quality, VAM

Introduction
The litchi (*Litchi chinensis* Sonn.) is the most important sub-tropical fruit crop and belongs to the family Sapindaceae. Litchi is considered as the queen of the fruits due to its excellent quality, juicy fruit, excellent sugar and acid blend, characteristic pleasant flavour and for attractive colour and nutritional value. India ranks second in the world next to China in litchi production. The cultivation of litchi has increased from 85 thousand ha in 2014-2015 to 90 thousand ha in 2015-2016. The production of litchi is mainly confined to Bihar (40 %), West Bengal (16 %), Jharkhand (10 %), Assam (8.2 %), Chhatisgarh (6.4 %), Uttarakhand (5.2 %) and to a smaller extent in Punjab, Odisha and Tripura. Punjab recorded the highest productivity with 16.14 MT/ ha (Anonymous, 2015) [1].
It comes to the market in the months of May-June when the market is full of other fresh fruits. In spite of the availability of different types of fruits in the market, the demand for fresh litchi is always very high due to its unique taste, flavour and colour. The food value of litchi mainly lies in its sugar and acid contents which again vary due to cultivars and climate. The litchi fruit consists of about 60 % juice, 8 % rag, 19 % seed and 13 % skin which varies depending upon the variety and the climate under which it is grown. There is an extreme need to make Indian litchi globally competitive since it is highly export oriented in nature and has great latent to earn foreign exchange in the international markets. The short span of availability of fruits coupled with poor shelf-life limits the duration of availability of fruits in national and international markets.
The widespread production of litchi fruit is limited by high sensitivity to soil and climatic conditions and short post harvest life. The litchi plant requires cool dry winters and warm wet summers for good production. Both low and high temperatures (Menzel and Simpson, 1988) [13],

nutrients (Qui *et al*., 1999) and irrigation (Li *et al*., 2001) [9] may result in undesirable yield losses or decreased fruit quality (Waseem *et al*., 2002) [24]. Litchi plants have shallow active root zones and hence fertilizers should be kept on soil surface with light working. The skin cracking of litchi fruits exposes the aril to external environments and provides entry to fungal pathogens resulting in rapid decay. Continuous application of chemical fertilizers without organic sources causes problem of soil health, while sole use of organic manures without augmentation of inorganic fertilizers may not be able to meet the high nutrient requirement of the crop due to bulk and slow acting nature of these fertilizer sources (Marathe *et al*., 2009) [12]. Fertilizer is one of the most important inputs for improving production and productivity of litchi orchards. Inadequate nutrition often attributed to low yields in litchi (Menzel and Simpson, 1987) [14] and poor quality of litchi fruit. To ensure high economic productivity and to sustain the available nutrient status in the soil at the desired level, correct doses of manures and fertilizers must be applied by use of reliable diagnostic tools designated to avoid nutrient imbalance.

The crop has tremendous export potential. It has been identified as one of the potential fruits for export. Hence, production of quality fruit of international standards is of utmost importance. Chemical fertilizers are mostly in use for their cultivation which has deleterious effect on soil, water and the environment. In Arunachal Pradesh, the commercial cultivation of litchi is in rudimentary stage. The major reason for slow spread of litchi cultivation in this regions are lack of scientific practices of cultivation, resulting in low productivity and low quality, serious pest and disease incidence, lack of processing industry, market information, transportation etc. In contrary, the demand of the fruits in the local market as well as outside is very high during the season. Keeping in view the high market demand of litchi, it is necessary to encourage the farmers for litchi cultivation which will give good returns to them.

Chemical fertilizers are mostly in use for their cultivation, which have some deleterious effect on fruit quality besides adverse effect on soil, water and environmental conditions. One such alternative is an integrated nutrient management that avoids depletion of soil organic matter and plant nutrients, besides suppression of some insect pests and diseases (Gaur, 2001) [5]. Bio-fertilizers or microbial inoculants are carrier based ready to use live bacterial or fungal formulations, which on application to plants, soil or composting pits, help in mobilization of various nutrients by their biological activity. An integrated use of organic manures, bio-fertilizers and chemical fertilizers could help in achieving the goal of obtaining safer food and environment for the people. Litchi crop is highly responsive to fertilizers and exhibit sensitivity to availability of nutrients. Considering the importance of the crop, there is a need to study about the integrated nutrient management of litchi in the foothills of Arunachal Pradesh.

Materials and Methods

The experimental site was Fruit Research Farm, Department of Fruit Science, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh. The geographical location of the research farm is 28° 04’ 43” N latitude and 95° 19’ 26” E longitude and having an altitude of 153 m above mean sea level. The prevailing climatic condition of Pasighat is sub-tropical humid and maximum rainfall occurs between April and September. The experiment was laid out in Randomized Block Design (RBD) with nine treatments and three replications with three plants in each replication. The plants were planted at spacing of 6 m x 6 m. The fertilizers like urea, SSP (Single Super Phosphate), MOP (Murate of Potash) and biofertilizers like Azotobacter, PSM and VAM were applied along with FYM or vermicompost as per the treatment requirement at specific intervals. The treatments were T_1=1000 g N+500 g P+500 g K (control)., T_2=500 g N+250 g P+250 g K+ 50 kg Vermicompost., T_3=500 g N+250 g P+250 g K+100 kg FYM., T_4=500 g N+250 g P+250 g K+100 kg FYM+100 g PSM., T_5=500 g N+250 g P+250 g K+100 kg FYM+150 g Azotobacter., T_6=500g N+250 g P+250 g K+100 kg FYM+100 g VAM., T_7= 500 g N+250 g P+250 g K+ 100 kg FYM+150 g Azotobacter +100 g PSM., T_8=500 g N+250 g P+250 g K+ 100 kg FYM+150 g Azotobacter+100 g VAM., T_9=500 g N+250 g P+250 g K+100 kg FYM +150 g Azotobacter +100 g PSM+100 g VAM.

Result and Discussion

Most of the yield and quality parameters were significantly influenced by integrated nutrient management. The number of fruits per tree (1281) and fruit yield (28.36 kg/ tree) was found to be significantly increased by T_9 *i.e.* 500 g N+250 g P+250 g K+100 kg FYM +150 g Azotobacter+100 g PSM+100 g VAM. Significant increase in the yield of litchi was observed with the application of phosphorus. It is similar to the results of Dutta *et al.* (2010) [4] and Rathore *et al.* (2013) [19] in litchi. This may be due to the addition of organic matter and nutrients in to the soil through organic sources as well as solubilization of insoluble phosphate and fixed potassium by the organic acids released from the biofertilizers and manures, while decomposing. The physical parameter like fruit set was found to be significantly highest in T_8 (42 %). Also minimum fruit drop (60.47 %) and fruit cracking (4.58 %) were observed in T_8 *i.e.* 500 g N+250 g P+250 g K+ 100 kg FYM +150 g Azotobacter + 100 g VAM. These results were similar to Tripathi et.al (2015) [23] in strawberry. Increasing levels of nutrients enhanced the rate of dry matter production and resultant increased the number basis and weight basis. These observations were also similar Supriya *et al.* (2015) [22] and Kirad *et al.* (2010) [7]. Prakash *et al.* (2010) [16] also reported similar findings with regard to fruit characteristics and yield in papaya while Shangpong (2017) [20] and Kamei (2015) reported the similar effect in papaya and guava respectively. Manjare *et al*. (2018) [11] reported that application of Azospirillum and PSB with full dose of chemical fertilizers with the highest fruit set, number of fruits per tree and yield per tree in sapota.

The maximum total sugar (26.14 %) and reducing sugars (14.51 %) were recorded with treatment T_9. Non reducing sugar was found to be statistically non significant. However maximum non reducing sugar (11.04 %) was also found in T_9 (500g N+250g P+250g K+ 100 kg FYM +150 g Azotobacter + 100g PSM+100 g VAM). Maximum TSS was observed in T_8 (18.31 °B) *i.e.* 500 g N+250 g P+250 g K+ 100 kg FYM +150 g Azotobacter + 100 g VAM. The fruit quality with respect to titratable acidity did not change up to significant extent due to different fertilizer treatments although lowest acidity (0.24 %) was recorded in treatment T_9 (500 g N+250 g P+250 g K+ 100 kg FYM +150 g Azotobacter + 100 g PSM+100 g VAM). The quality improvement in fruits may be due to proper supply of nutrients and induction of growth hormones, which stimulated cell division, cell elongation, increase in number and weight of the fruits, better root development and better translocation of water and deposition of nutrients. This may also be attributed due to the improved fertilizer use efficiency with the application of organic sources of nutrients and bio-fertilizers (Singh, 2009) [9] apart from nutrient supply and availability. Significant influence of bio-fertilizers and chemical fertilizers on fruit quality was also reported by Athani *et al.* (2007) [2] and Ram and Pathak (2007) in guava and Madhavi *et al.* (2008) in mango. These findings are similar to the result of Rathore *et al*. (2013) [19]. The increased fruit quality may be explained from the fact that these microbial fertilizers enhances the nutrient availability by enhancing the capability of plant to better solute uptake from rhizosphere (Patel *et al*., 2005) and also helped in mitigating stress in plant (Krishna *et al*., 2006) [8].

Table 1: Effect of Integrated Nutrient Management on yield and fruit quality of litchi

	Yield attributing characters						Quality parameters			
Treatments	**No. of fruits per tree**	**Fruit set (%)**	**Fruit drop (%)**	**Fruit cracking (%)**	**Fruit yield (kg/tree)**	**Titratable acidity (%)**	**TSS (Brix)**	**Total sugars (%)**	**Reducing sugar (%)**	**Non-reducing sugar (%)**
T_1	804.67	38.11	80.57	7.93	14.68	0.25	15.27	17.43	10.98	6.13
T_2	881.00	38.35	81.22	6.37	18.58	0.26	17.38	23.73	13.31	9.90
T_3	873.33	40.94	69.16	6.70	16.79	0.30	17.05	22.81	13.63	8.72
T_4	913.67	41.95	64.18	6.03	16.96	0.35	17.81	25.48	14.47	10.45
T_5	703.00	39.92	66.44	7.33	15.64	0.28	18.23	23.47	13.51	9.46
T_6	990.33	39.87	70.28	6.82	20.73	0.25	16.58	23.25	13.08	9.66
T_7	1038.00	40.72	63.14	5.07	22.66	0.26	15.85	24.37	13.33	10.49
T_8	1098.33	42.00	60.46	4.58	24.30	0.27	18.31	23.23	13.52	9.22
T_9	1281.00	41.70	61.43	5.07	30.01	0.24	17.83	26.14	14.51	11.04
Mean	953.70	40.39	68.54	6.21	20.03	0.27	17.15	23.32	13.37	9.45
C.D 5%	131.92	0.76	2.80	0.59	2.76	NS	1.27	2.93	1.57	NS
SE(m)±	44.00	0.25	0.93	0.20	0.92	0.23	0.42	0.98	0.52	1.14

Conclusion

On the basis of above result, it can be concluded that integrated nutrient management in litchi Enhances yield and fruit quality to a greater extent. So for optimizing yield and quality of litchi fruit a dose of with 500 g N+250g P+250 g K+100 kg FYM +150 g Azotobacter +100 g PSM+100 g VAM should be added.

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