International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(3): 250-254

Received: 12-03-2018
Accepted: 16-04-2018

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Effects of graded levels of NPK on growth, flowering and yield attributing characters of shahi litchi (*Litchi chinensis* Sonn.)

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Abstract
Response of Graded Level of NPK on morphological growth, flowering and yield quality of Shahi cultivars of litchi (*Litchi chinensis* Sonn). The NPK was applied through ring basin (RB) applied in two different split doses. Application of NPK significantly affected canopy volume, trunk girth, spread, canopy height, panicle length, yield and number of fruits per tree. Among different graded levels of NPK the applied 100g nitrogen and 100g potassium (T_{18}) per year age of tree with 2/3 dose in April and 1/3 dose in June showed maximum canopy height (4.2m), maximum tree spread (7.75 m) and maximum canopy volume (32.14 m^3) while minimum height (3.5m) was observed with the application of 75g nitrogen and 100 g potassium (T_6) per year age of tree with 1/2 dose in April and 1/2 dose in June and minimum canopy volume, T_{13} (90.13 m^3) was recorded with the application of 75 g nitrogen and 50 g potassium. Maximum trunk girth (84 cm) was recorded with the application of 100 g nitrogen per year age of tree and 50 g potassium per year age of tree (T_7).The maximum panicle length (38.72 cm) was recorded with the application of 50 g nitrogen and 50 g potassium (T_1) per year age of tree with 1/2 dose in April and 1/2 dose in June. The treatment consisting of 75:50:100 (T_{15}) i.e.75 g nitrogen and 100 g potassium per year age of tree recorded the maximum yield of 128.00 kg per tree, while minimum fruit yield (51.25 kg per tree) was recorded with 50 g nitrogen and 100 g potassium in (T_{12}). All the treatment showed 50% flowering stage and fruit set between 9th - 16th March and 21st–27th March respectively. Days taken from panicle emergence to fruit set was 50-55 days.

Keywords: NPK, ring basin, growth, flowering, yield, quality, litchi etc

Introduction
Litchi (*Litchi chinensis* Sonn.) is an important subtropical evergreen fruit crop belongs to family Sapindaceae, and is believed to be originated in Southern China. Fertilizer is one of the most important, input for improving productivity and production of litchi orchards. Proper nutrient management is the key for achieving higher production and quality fruits. Inadequate nutrition often attributes to low yields (Menzel and Simpson, 1987) and poor quality of litchi. The acute shortage of N, P and K was observed to stunt all forms of litchi growth including floral initiation (Goldweber, 1959) [4]. 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. To apply correct dose of nutrients at proper time, reliable diagnostic tools designated to avoid nutrient imbalance (Bhargava and Chadha, 1993) [6] is necessary. The quantity and type of fertilizers to be used in a litchi grove are largely influenced by soil type, age of tree and bearing potential of cultivars. Zhang *et al*.,(1999) [5] classified the growth of litchi according to tree age into 4 different phases, viz., young non-bearing phase (1-3 years), young bearing phase (3-10 years), junior adult bearing phase (10-20 years) and senior adult bearing phase (>20years). Nutrients requirement and balance at different phase are different.
The right nutrient balance is essential to maintain fruit quality. Nutrients with the most notable influence on fruit quality are nitrogen, phosphorus, potassium and calcium (Fallahi *et al*., 1985) [7]. In Litchi nutrition management is based on monitoring the leaf and soil nutrient levels and adjusting fertilizer practices according to the yields obtained (Menzel *et al*., 1992; Menzel, 2001). Leaf analysis is a useful diagnostic tool for optimizing mineral nutrition in fruit trees and its good correlation with fruit yield and quality has been reported (Fallahi and Simons, 1996) [8].
Tissue analysis has proved valuable in assessing the nutritional status of tree crops (Shear and Faust, 1980), and leaf standards have been updated for litchi (Menzel *et al*., 1992).

As Litchi is relatively new crop in terms of detail research on balance nutrition and therefore very limited attempts in India have been made to analyses effect of different doses of nutrients on growth and performance. Litchi being a perennial crop needs long term study to develop guidelines and nutrient index. Further as leaf nutrient content hold promise to be an effective index for nutrient application. Therefore, the study on "Effect of Graded Level of NPK on Growth, Flowering and Yield Attributing Characters of Shahi Litchi (*Litchi chinensis* Sonn.)" has been carried out with the objectives to evaluate vegetative and reproductive performance under different level of N and K doses.

Materials and Method

The experiment was conducted during 2016- 2017 at Experimental Farm of ICAR-National Research Centre on Litchi, Mushahari, Muzaffarpur, Bihar. The experimental site is situated at $26^0$5'87" N latitude, $85^0$26'64" E *longitude* at an elevation of 210 m above the mean sea level having a sub-tropical climate. The experimental soil was alluvial with sandy loam texture and are calcareous having pH 7.5 - 8.0. The experiment was conducted on eleven year old trees of litchi cv. Shahi planted at 8 m distance in a square geometry and maintained under uniform cultural practices. The chosen design was 3 factors Factorial Randomized Block Design with 3 replication,two tree as treatment unit and tree spacing is 8.0 m x 8.0 m with 18 numbers of treatments with methods of application Ring basin (1.5-2.0 m away from the trunk) consisting three levels of Nitrogen and Potassium were maintained at (50:75:100 and 50:75:100 g/plant/year) respectively. Symbols used for N were as follows: N_1: 50 g/plant/year**,** N_2: 75 g/plant/year**,** N_3: 100 g/plant/year and that of K were: K_1: 50 g/plant/year, K_2: 75 g/plant/year, K_3: 100 g/plant/year and Phosphorous: 50 g/plant/year. Two different splits of fertilizers were applied in the month of June and April and symbol used were as follows: M_1:1/2 dose in June 2016 (After harvest) and 1/2 dose in April 2017 (at Clove size fruit stage) and M_2:2/3 dose in June 2016 (After harvest) and 1/3 dose in April 2017 (Clove size fruit stage)

Fertilizers were applied through ring basin method 30 cm away from the trunk and were mixed with soil. The nitrogen and potassium were applied in split doses, ½ dose after harvest and ½ dose at fruit development stage from T_1-T_9 and 2/3 dose after harvest and 1/3 dose at fruit development stage from T_{10}-T_{18}. Each treatment was replicated thrice with a two tree as a treatment unit. All the experimental trees were given uniform cultural practices as recommended by NRCL, Muzaffarpur, Bihar.

Under growth parameters, the observations were recorded on tree height, trunk girth, canopy height, and canopy diameter and canopy volume. The height of the tree was measured vertically from the ground to the tip of the tree and expressed in meter. The trunk girth was measured at 30 cm above from the base and expressed in centimetre. The canopy height was taken from place of first branching of main stem to the apex of the canopy and recorded in meter. The diametric length of the ground space occupied by the tree was measured in two directions and the canopy spread was recorded as "North-South and "East-West directions and final canopy diameter was calculated by addition of both direction divided by 2. The canopy volume was calculated as per formula of Westwood and Robert (1970) [15], i.e.

$$\text{Tree volume}\,(m^3) = \frac{1}{8} S^2 \pi\,(H - 0.38)$$

Where S= Mean of spread, H= Height of tree, π= 3.14

Data were recorded on the panicle length by selecting 5 panicles in each direction and was measured by measuring scale and expressed in centimeter, after getting the average of all direction, Girth of primary branches was measured in centimeter with the help of measuring tape.

The data on yield was recorded by weighing all the fruits under each treatment replication with the help of a top pan balance (10 kg capacity) at the time of harvesting. The number of fruits per kg was also calculated, Fruit size in terms of length from apex to stem (mm) and maximum diameter (mm) was measured by Vernier calipers, Fruit weight was calculated by recording the weight of 10 fruits in each of the three replications. Fruits were weighed on physical balance and average fruit weight was expressed in gm, Pericarp weight was recorded by taking peels of 10 fruits in each of the three replications. Average peel weight was expressed in gm, Pulp weight was recorded by weighing pulp of 10 fruits in each of the three replications and average pulp weight was expressed in gm, Seed weight was recorded by weighing separated seed in 10 fruits in each of the three replications and average seed weight was expressed in gm, Dates to 50 per cent flowering: The date when male flowering phase and female flowering phase was observed on the panicle was noted, Date of fruit set the drying up of the stigma and enlargement of either one or both the locules, notify the beginning of the fruit set. The date of fruit initiation was thus recorded for all the treatments under study; Days to full maturity the no. of days required by fruits from fruit set to reach full mature stage was recorded.

The mean was computed for the data on various attributes, whereas a three-factor analysis of variance (ANOVA) using a Factorial randomized block design (RBD) was conducted with SAS 9.2 statistical software for the data on quality parameters. The least significant differences (LSDs) between means at $P_{0.05}$ and the standard error (SE) of means were computed.

Results and Discussion

The data pertaining to tree height (m), trunk girth (cm), canopy height (m), canopy diameter (m), canopy volume (m^3), and Panicle length (cm) has been presented table-1.1 and 1.2, results indicates that the effect of tree height (m) is revealing that the different treatments did not show significant effect however a marginal increase in the height was observed with the application of 50 g nitrogen and 100 g potassium (T_{12}) per year age of tree i.e. 6 m. Similar findings were also reported by Baksh *et al.* (2008) [10], which was observed in guava cv. 'Sardar' that the maximum increment in growth parameter viz., plant height was recorded with the treatment where 100 per cent NPK + 250 g PSB + 250 g Azotobacter were applied on the trees.) The data pertaining to the effect of graded level of NPK on canopy height are presented in Table 1.1.The maximum canopy height (4.2 m) was recorded with the application of 100 g nitrogen and 100 g potassium (T_{18}) per year age of tree with 2/3 dose in April and 1/3 dose in June, while minimum height (3.5m) was observed with the application of 75g nitrogen and 100 g potassium(T_6) per year age of tree with 1/2 dose in April and 1/2 dose in June. Similar findings were also reported by Rai *et al.* (2002) [11] in litchi cv. 'China' where the maximum height, east-west spread and tree volume were recorded with application of its highest level of nitrogen i.e.2, 000 g N/tree/year. Trunk girth (cm) is clear from the Table 1.1, that all the plants under treatments are significantly affected due to Graded Level of NPK;

however, the maximum trunk girth (84 cm) was recorded with the application of 100 g nitrogen per year age of tree and 50 g potassium per year age of tree (T_7). Similar findings were also reported by Singh and Pathak (1983), who obtained best height and trunk girth by applying 61 g N, 41 g P_2O_5 and 61 g K_2O /tree per year of age in litchi cv. Calcuttia. The data pertaining in Table 1.2 revealed that the different treatments show significant effect on tree spread. Maximum tree spread (7.75 m) was recorded with the application of 100 g nitrogen and 100g potassium per year age of tree (T_{18}). Sharma and Mahajan (1998) conducted field experiments conducted at Gurdaspur, India, trees of *L. chinensis* cv. Calcuttia, it was found that north-south and east-west spread were greatest for trees supplied with a total of 1.0 kg N+250g P_2O_5+250 g K_2O. The data on the effect of graded level of NPK on the canopy volume are presented in Table 1.2. Maximum Canopy Volume (132.14 m^3) was recorded with the application of 100 g nitrogen and 100g potassium per year age of tree (T_{18}), while minimum was recorded with the application of 75 g nitrogen and 50 g potassium per year of age of tree T_{13} (90.13 m^3). Similar findings were also reported by Rai *et al.* (2002) [11], who observed that in litchi cv. 'China' that the maximum tree volume was recorded with 2,000 g N/tree/year, whereas the maximum trunk girth in north- south spread was recorded with 500 g N/tree/year. The data pertaining to the effect of graded level of NPK on panicle length are presented in Table 1.1. The maximum panicle length (38.72 cm) was recorded with the application of 50 g nitrogen and 50 g potassium (T_1) per year age of tree with 1/2 dose in April and 1/2 dose in June. The minimum height (26.24 cm) was observed with the application of 75 g nitrogen and 50 g potassium (T_{13}) per year age of tree with 2/3 dose in April and 1/3 dose in June.

The data pertaining to Fruit Yield (kg/tree), No. of fruits per tree, Dates to 50% Flowering, Dates to Fruit set, Days to full maturity, recording during has been presented Table-1.2 and 1.3, results indicated that the effect of graded level of NPK on Fruit yield is presented in Table 1.2. It is evident from that the different treatments caused significant variation in fruit yield. The treatment consisting of 75:50:100 (T_{15}) i.e.75 g nitrogen and 100 g potassium per year age of tree with 2/3 dose in April and 1/3 dose in June recorded the maximum yield of 128.00 kg per tree, while minimum fruit yield (51.25 kg per tree) was recorded with 50 g nitrogen and 100 g potassium in (T_{12}). Lal *et al.* (1999) [14] reported the influence of seven levels of nitrogen and potassium on 14 -year -old litchi cv. Rose scented trees from 1989 to 1991 in Uttar Pradesh, India. Nitrogen at the rate of 1200g and potassium at the rate of 600 g per tree gave better growth and yield. The data on the effect of graded level of NPK on No. of fruits/tree is presented in Table 1.2. It is evident from that the different treatments caused significant variation in fruit yield. The treatment dose 100g nitrogen and 75 g potassium (T_{17}) recorded the maximum no. of fruit/tree 6286 fruits per tree, while minimum (2500 fruits per tree) was recorded with the application of 50 g nitrogen and 100 g potassium in (T_{12}). Similar findings was observed by Pathak and Mitra (2008), who found number of fruits increased with the increase in the level of potassium from 0 to 700 g/plant/year, but thereafter it decreased with 1050 g K_2O/plant/year. Dates to 50% flowering the 50% flowering include male flowering phase and female flowering phase. All the treatment had their 50% flowering stage ranges from 9th - 16th March. The data on the effect of graded level of NPK on Dates to 50% Flowering is presented in Table 1.4. Dates to Fruit s*et al*l the treatments set their fruit between 21st to 27th March. It takes 50-55 days from panicle emergence to fruit set. The data on the effect of graded level of NPK on Dates to Fruit set is presented in Table 1.4. Days to full maturity the data pertaining on the effect of graded level of NPK on Days to full maturity is presented in Table 1.4. The no. of days required from fruit set to reach full maturity varies from 51-56 days in T_6 to 63-66 days in T_4.

Summery and Conclusion

Litchi, one of the delicious fruits of world, is also an important crop of Bihar. It constitutes a significant area of horticultural crops in the state. In comparison to other fruit tree the young plants grow slowly. Several attempts have been made to standardize nutrient requirements of litchi tree in India but in all cases the requirement has been worked out for grown up (bearing trees). The recommendations made for grown up tree cannot be used for young trees because of some obvious physiological reasons and physical differences between the two age groups. Fertilization is the most important management factors which control plant development, fruit yield and quality.

Application of 100 g nitrogen and 100 g potassium (T9) with half dose in June and half in April significantly influenced vegetative growth parameters (plant height, plant spread, stem girth, girth of primary branches and tree volume).Fertilizer doses were also significantly affecting plant height, plant spread,stem girth, girth of primary branches and tree volume. Increasing the level of fertility from 50 g N/plant/year to 100 g N/plant/year brought a significant increase in average plant height, plant spread, stem girth, girth of primary branches and tree volume in litchi plants. Interaction of Nitrogen x Potassium x Splitting dose (2/3 in June and 1/3 in April) was significantly affecting plant height, plant spread and tree volume. A significant response of graded level of NPK on fruit yield was recorded.

The treatment consisting of 75:50:100 (T15) found to be attributing maximum yield (128.00 kg per tree),and the maximum number of fruits per tree i.e. 6286 fruits per tree with treatment dose 100 g nitrogen per tree age of tree and 75 g per tree age of tree potassium T17 (100:50:75).

The best results in terms of growth, yield and flowering behaviour was found significant with interactions. In terms of yield,75 g N+100 g K per year age of tree in 2 split i.e. [2/3rd in June and 1/3rd in April was found maximum]

Treatments details

$M_1N_1K_1(T_1)$	½ dose in June 2016 and ½ dose in April 2017+50g/plant/year N+50 g/plant/year K
$M_1N_1K_2(T_2)$	½ dose in June 2016 and ½ dose in April 2017+50 g/plant/year N+75 g/plant/year K
$M_1N_1K_3(T_3)$	½ dose in June 2016 and ½ dose in April 2017+50 g/plant/year N+100 g/plant/year K
$M_1N_2K_1(T_4)$	½ dose in June 2016 and ½ dose in April 2017+75 g/plant/year N+50 g/plant/year K
$M_1N_2K_2(T_5)$	½ dose in June 2016 and ½ dose in April 2017+75 g/plant/year N+75 g/plant/year K
$M_1N_2K_3(T_6)$	½ dose in June 2016 and ½ dose in April 2017+75 g/plant/year N+100 g/plant/year K
$M_1N_3K_1(T_7)$	½ dose in June 2016 and ½ dose in April 2017+100 g/plant/year N+50 g/plant/year K

$M_1N_3K_2(T_8)$	½ dose in June 2016 and ½ dose in April 2017+100 g/plant/year N+75 g/plant/year K
$M_1N_3K_3(T_9)$	½ dose in June 2016 and ½ dose in April 2017+100 g/plant/year N+100 g/plant/year K
$M_2N_1K_1(T_{10})$	2/3dosein June 2016 and 1/3 dose in April 2017+50 g/plant/year N+50 g/plant/year K
$M_2N_1K_2(T_{11})$	2/3 dose in June 2016 and 1/3 dose in April 2017+50 g/plant/year N+75 g/plant/year K
$M_2N_1K_3(T_{12})$	2/3 dose in June 2016 and 1/3 dose in April 2017+75 g/plant/year N+100 g/plant/year K
$M_2N_2K_1(T_{13})$	2/3 dose in June 2016 and 1/3 dose in April 2017+75 g/plant/year N+50 g/plant/year K
$M_2N_2K_2(T_{14})$	2/3 dose in June 2016 and 1/3 dose in April 2017+75 g/plant/year N+75 g/plant/year K
$M_2N_2K_3(T_{15})$	2/3 dose in June 2016 and 1/3 dose in April 2017+100 g/plant/year N+100 g/plant/year K
$M_2N_3K_1(T_{16})$	2/3 dose in June 2016 and 1/3 dose in April 2017+100 g/plant/year N+50 g/plant/year K
$M_2N_3K_2(T_{17})$	2/3 dose in June 2016 and 1/3 dose in April 2017+100 g/plant/year N+75 g/plant/year
$M_2N_3K_3(T_{18})$	2/3 dose in June 2016 and 1/3 dose in April 2017+100 g/plant/year N+100 g/plant/year K

Table 1.1: Effect of graded level of NPK on tree height, Canopy height, Panicle length and Trunk girth of litchi cv. Shahi

Treatments	Tree height	Canopy height	Panicle length	Trunk girth
$M_1N_1K_1(T_1)$	5.3	3.8	28.5	74
$M_1N_1K_2(T_2)$	5.2	3.9	31	80
$M_1N_1K_3(T_3)$	4.8	3.6	30.4	80
$M_1N_2K_1(T_4)$	5.4	4.2	28.5	73
$M_1N_2K_2(T_5)$	5.2	3.6	31	70
$M_1N_2K_3(T_6)$	4.9	4.2	30.4	82
$M_1N_3K_1(T_7)$	5.3	4.2	28.5	84
$M_1N_3K_2(T_8)$	5.3	4.2	31	76
$M_1N_3K_3(T_9)$	5.4	3.6	30.4	79
$M_2N_1K_1(T_{10})$	5.1	4.2	28.5	80
$M_2N_1K_2(T_{11})$	5.1	4.2	31	78
$M_2N_1K_3(T_{12})$	6.0	3.6	30.4	68
$M_2N_2K_1(T_{13})$	4.7	4.2	28.5	70
$M_2N_2K_2(T_{14})$	5.3	4.2	31	80
$M_2N_2K_3(T_{15})$	5.4	3.6	30.4	79
$M_2N_3K_1(T_{16})$	5.5	4.2	28.5	80
$M_2N_3K_2(T_{17})$	5.2	4.2	31	73
$M_2N_3K_3(T_{18})$	5.6	3.6	30.4	80
C.D.	N/S	3.797	2.086	7.148
$S.E_m$	0.307	1.321	0.726	2.487

*Figures at p=0.05 as tested by randomized block design. [CD (p=0.05), CD (p=0.05)].

Table 1.2: Effect of Graded Level of NPK on Canopy volume, Canopy spread, Yield (kg/tree) and No. of fruits/tree in litchi cv. Shahi

Treatments	Canopy volume	Canopy spread	Yield	No. of fruits /tree
$M_1N_1K_1(T_1)$	96.2	7	51.71	2,625
$M_1N_1K_2(T_2)$	98.7	7	103.7	4,860
$M_1N_1K_3(T_3)$	99.1	7.3	79.34	4,069
$M_1N_2K_1(T_4)$	92.3	6.8	99.79	5,040
$M_1N_2K_2(T_5)$	99.1	7.2	109.32	5,578
$M_1N_2K_3(T_6)$	87.3	6.9	58.01	2,990
$M_1N_3K_1(T_7)$	110	7.4	83.16	4,200
$M_1N_3K_2(T_8)$	105	7.1	116.4	6,000
$M_1N_3K_3(T_9)$	106	7.1	118.3	5,580
$M_2N_1K_1(T_{10})$	96.8	7	113.93	5,813
$M_2N_1K_2(T_{11})$	90.9	6.9	91.41	4,688
$M_2N_1K_3(T_{12})$	104	7.1	51.25	2,500
$M_2N_2K_1(T_{13})$	90.1	6.4	104.55	5,100
$M_2N_2K_2(T_{14})$	99.8	6.9	66.69	3,420
$M_2N_2K_3(T_{15})$	100	7.2	128	6,010
$M_2N_3K_1(T_{16})$	123	7.5	110.8	5,775
$M_2N_3K_2(T_{17})$	103	7.4	115.6	6,286
$M_2N_3K_3(T_{18})$	132	7.8	106.4	5,268
C.D.	3.797	N/S	9.933	406.3
$S.E_m$	1.321	0.121	3.455	141.3

*Figures followed at p=0.05 as tested by randomized block design.[CD (p=0.05), CD (p=0.05)].

Table 1.3: Effect of Graded Level of NPK on Flowering, Fruit set and Full maturity stage

Treatments	Dates to 50% flowering	Dates to fruit set	Days to full maturity
T_1	10th March 2017	23rd March 2017	61-65 days
T_2	13 th March 2017	22nd March 2017	58-60 days
T_3	11 th March 2017	23rd March 2017	55-61 days
T_4	10th March 2017	24th March 2017	63-66 days
T_5	9th March 2017	21st March 2017	60-65 days
T_6	12th March 2017	25th March 2017	51-56 days
T_7	15th March 2017	26th March 2017	57-62 days
T_8	13th March 2017	27th March 2017	53-60 days
T_9	14th March 2017	21st March 2017	61-66 days
T_{10}	11th March 2017	23rd March 2017	62-64 days
T_{11}	16th March 2017	25th March 2017	56-58 days
T_{12}	13th March 2017	26th March 2017	55-60 days
T_{13}	16th March 2017	25th March 2017	57-62 days
T_{14}	14th March 2017	24th March 2017	55-60 days
T_{15}	15th March 2017	22nd March 2017	54-61 days
T_{16}	13th March 2017	25th March 2017	62-65 days
T_{17}	16th March 2017	24th March 2017	54-60 days
T_{18}	14th March 2017	21st March 2017	61-66 days

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