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Effect of foliar sprays of NAA and boron on flowering, fruiting, fruit retention and yield of litchi (*Litchi chinensis* Sonn.)

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Abstract
The experiment was carried out at Horticulture Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur (U.P.) during the years 2017-18 and 2018-19. Sixteen treatments viz. four levels of NAA (0, 30, 60 and 90 ppm) and Boron (0, 0.2, 0.4 and 0.6%) were studies in a Factorial Completely Randomized Design with three replications. Spraying were done twice i.e. before flowering (10 Feb.) and at pea stage (06 April) during both the years. Application of individual sprays of NAA 60 ppm significantly maximized length of panicle (33.13 and 35.03 cm), number of fruits at pea stage (44.51 and 47.50), fruit retention per panicle at maturity stage (23.78 and 25.43), fruit length (3.06 and 3.26 cm), fruit diameter (2.84 and 2.98 cm), fruit weight (19.04 and 20.10 g) and yield of marketable fruits per plant (70.03 and 73.40 kg) in corresponding years, whereas, days to flowering was hastened taking (23.42 and 21.73 days). Sprays of 0.4% boron elongated shoot length significantly (24.75 and 26.71 cm), number of fruits at pea stage (42.16 and 45.29), fruit diameter (2.79 and 2.92 cm), fruit weight (19.22 and 20.08 g) in respective years and 0.6% boron significantly enhanced fruit retention per panicle at maturity (22.62 and 24.29) and yield of marketable fruits per plant (65.21 and 68.55 kg), whereas, length of panicle (33.42 and 35.32 cm) and fruit length (3.09 and 3.29 cm) were enhanced and days to flowering was earliest (23.66 and 21.99 days) with 0.4% boron during previous year and 0.6% boron sprays during final year. Regarding interaction effect marketable yield per plant was found significantly highest (74.64 kg) under interactive treatment N_2 B_2 during previous year only.

Keywords: Litchi, boron, NAA, flowering, fruit size, weight and marketable yield

Introduction
The litchi (*Litchi chinensis* Sonn.) is an important subtropical evergreen fruit crop belonging to family sapindaceae and is believed to have originated in the South China. Its cultivation is restricted due to specific climate. In India 568000 metric tonnes of litchi is produced annually from 93000 hectares (NHB, 2016). It is grown in Sub-mountaineous districts of Uttar Pradesh i.e. Saharanpur and Muzaffarnagar. It can also be successfully cultivated in Rampur, Barielly, Bahraich, Khiri and Pilibhit districts of Uttar Pradesh (Singh and Singh, 1954) [24]. It is highly valued by virtue of its delicious taste excellent flavour, pleasant fragrance, attractive appearance and high nutritional values and therefore, it possesses great potentiality for accelerated export. In view of the above systematic efforts have not been made to improve the yield and quality of litchi fruits, However, erratic studies have been made to enhance these with the aid of micronutrient B. Ca & Cu (Kaur, 2017) [11-12] growth regulator particularly GA_3, NAA, 2,4 D (Rajput and Chand, 1975) [18]. Therefore, an investigation was planned to find out the optimal level and time of application of growth regulator & micronutrient.

Materials and Methods
The present experiment was conducted at Horticulture Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur during the year 2017-18 and 2018-19. There were 16 treatments tried in a Factorial Completely Randomized Design with three replications. Uniform and healthy sixteen plants of litchi cv. Dehradun were selected and on each plant similar three branches were identified and tagged as unit. NAA 0, 30, 60 and 90 ppm and Boron 0, 0.2, 0.4 and 0.6% were sprayed twice i.e. first spraying on 10 Feb. before initiation of inflorescence and second at pea stage on 06 April during both the years. All the manurial requirement, cultural practices and plant protection measured were adopted as per norms. Five panicles in each direction were selected randomly in each

treatment for recording days to flowering, length of panicle (cm), fruit retention at maturity, size, weight of fruit and marketable yield per plant (kg). Observations on size and weight were recorded by routine methods. Blemished, cracked and very small fruits were discarded and remaining ones were taken as marketable.

Results and Discussion

All the concentrations of NAA caused earlier flowering and the earliest was 23.42 and 21.73 days observed under 60 ppm treatments during 2017-18 and 18-19 respectively. The plants under control delayed it to the maximum taking 25.80 and 23.75 days. Earlier flowering was improved 9.22 and 8.50% due to 60 ppm sprays of NAA over control during respective years of trial. All the doses of boron hastened flowering during both the years. Untreated plants took maximum (24.92 and 23.17) days for flower initiation, whereas, the plants under 0.4% concentration took the minimum (23.66 days) period in first year and 0.6% in second year (21.99 days) for flower initiation ranged from 23.66 to 24.92 and 21.99 to 23.17 during corresponding years. It was registered 5.05 and 5.09% earlier during respective years. These findings are in line with the reports of Kundu and Mitra (1999) [15], Balakrishnan (2000) [3], Ram *et al.,* (2016) [19] in guava and Mishra *et al.,* (2012) [16] in litchi.

Lengths of panicles under NAA 60 ppm were measured 33.13 and 35.03 cm being significantly longest than control which showed shortest 30.06 and 31.89 cm panicles respectively. The length of panicle ranged from 30.06 to 33.13 cm and 31.89 to 35.03 cm during respective years. Improvement in this regard caused by 60 ppm NAA was 10.21 and 9.84%. Boron at 0.4% and 0.6% prolonged panicle exhibiting 33.42 and 35.32 cm length during first and second year of study respectively. The shortest of panicles measuring 29.21 and 31.21 cm were recorded under boron control. The range of panicle length was 29.21 to 33.42 and 31.21 to 35.32 cm during corresponding years of study. The improvement in length of litchi panicles was observed 14.14 and 14.51% over control. Boron is helpful in maintaining better nutritional status of the plants which in the present trial led to beneficial effect in producing to longer panicle. The findings are in accordance with the reports of Rajput and Chand (1975) [18] in guava, Dabas and Jindal (1985) [7] in grapes and Babu and Singh (2001) [1] in litchi.

NAA 60 ppm revealed significantly highest of 44.51 and 47.50 fruits per panicle at pea stage against the minimum of 37.12 and 40.09 under control during corresponding years of study. The treatment caused better retention of fruits showing improvement of 19.90 and 18.48% under control respectively. Boron also proved effective in fruit retention and 0.4% concentration exhibited significantly maximum retention of 42.16 and 45.29 fruits during former and latter years of trial respectively. Panicles devoid of boron nutrition borne the minimum of 40.02 and 43.08 fruits at pea stage. Foliar treatment of boron brought about of 5.34 and 5.12% improvement over control. These findings get supports from the work of Sakar and Ghosh (2009) [22] and Singh and Kaur (2016) [25] who reported similar results in litchi

The retention of fruits at maturity was recorded significantly greater with NAA 60 ppm treatment (23.78 and 25.43) fruits respectively against the poorest (19.52 and 20.95) achieved under control (N_0). The fruit retention at maturity ranged from 19.52 to 23.78 and 20.95 to 25.43 in respective years. However, there was an improvement of 21.82 and 21.38% respectively over control. Boron also proved effective in fruit retention but not to the tune of NAA and its 0.6% concentration significantly maximized (22.62 and 24.29) the attributes. The minimum of 21.19 and 22.77 fruits were retained under control (B_0). The retention, however, ranged from 21.19 to 22.62 and 22.77 to 24.29 exhibiting an improvement of 6.74 and 6.67% over control respectively.

NAA application gradually improved the fruit size in terms of their length and diameter up to 60 ppm revealing 3.06, 3.26 cm and 2.84, 2.98 cm values respectively. NAA control expressed significantly smaller length (2.70 and 2.92 cm) and diameter (2.41 and 2.56 cm) during corresponding years. Fruit length ranged from 2.70 to 3.06 and 2.92 to 3.26 cm and diameter 2.41 to 2.84 cm and 2.56 to 2.98 cm during respective years. The beneficial role of NAA in fruit retention might be due to its involvement in cell division, cell elongation and increased volume of intercellular spaces in the mesocarpic cells which could have boosted plant health thereby producing health and larger fruit which ultimately proved helpful in fruit retention. (Kaur and Kaur, 2017) [11-12]. The findings of the present investigation are in agreement with the reports of Chaudhary *et al.,* (2018) [5] in aonla and Sahay *et al.,* (2018) [21] in litchi. Foliar spray of 0.4% boron proved most effective to improving fruit size barring length during latter year; however, fruit length was 3.09 cm during 2017-18 and diameter was recorded 2.79 and 2.92 cm during corresponding years. Significantly smallest fruit have (2.62, 2.85 cm) length and (2.47, 2.63 cm) diameter were harvested from control (B_0). Fruit length ranged from 2.62 to 3.09 cm and 2.85 to 3.29 cm and diameter 2.47 to 2.79 cm and 2.63 to 2.92 cm respectively. Improvement in fruit length and diameter were recorded as 17.93, 15.43% and 12.95, 11.02% over control respectively during corresponding years. The significant roles played by boron in boosting the fruit size in the present investigation may be attributed to its optimal dose whose involvement in hormonal metabolism, increased cell division, elongation and expansion of cells could have caused desirable improvement. These findings are in line with the reports of Babu and Singh (2002) [2], Dixit *et al.,* (2013) [8] and Kaur (2017) [11-12] in litchi.

NAA 60 ppm produced significantly heaviest fruits (19.04 and 20.10 g) against lighter 17.69 and 18.57 g fruits under control (N_0) during respective years. The range of fruit weight varied from 17.69 to 19.04 g and 18.57 to 20.10 g during respective years. However, 60 ppm spray caused improvement to the tune of 7.63 and 8.23% over control respectively. The greater size of fruits with NAA treatment as discussed earlier obviously brought about heavier fruits. It may be attributed to the NAA involvement in cell division, cell expansion and increased volume of intercellular mesocarpic cell of fruit which obviously enhanced the weight of fruits. These findings are in line with the reports of Shrestha and Koirala (2007) [23], Dutta *et al.,* (2011) [9], Sultana *et al.,* (2016) [26] and Sahay *et al.,* (2018) [21] in litchi. Boron applied @ 0.4% significantly maximized 19.22 and 20.08 g fruit weight against significantly lightest (17.37 and 18.57 g) recorded under control. Fruit weight ranged from 17.37 to 19.22 g and 18.57 to 20.08 g in respective years. The weight, however, increased by 10.65 and 8.13% respectively over control. Boron plays an important role in vegetative growth, flowering and fruiting, by virtue of improvement in respiration and photosynthesis. In the present investigation it may have helpful mobilization of food materials to the fruits which is helpful in increasing their size and weight. The findings are in accordance with the reports of Babu and Singh

(2002), Dixit *et al.,* (2013) [8], Haq *et al.,* (2013) and Kaur (2017) [11-12] in litchi.

To ascertain the yield of marketable fruits all the cracked and other blemished fruits were separated from total yield. The treatment of 60 ppm NAA gave the significantly highest yield of 70.03 and 73.40 kg marketable fruits per plant. against the lowest (48.56 and 51.40 kg) under control during respective years of study. The improvement of 44.21 and 42.80% over control was noted under 60 ppm NAA respectively. The increase in yield owing to NAA may be attributed to its physiological activities in the plants which could have checked fruit drop reduced fruit cracking and minimized number of blemished fruits considerably thereby increasing yield as well as marketable yield. These findings are in agreements with the reports of Sultana *et al.,* (2016) [26], Sahay *et al.,* (2018) [21] and Chauhan *et al.,* (2019) [6] in litchi. Foliar nutrition of boron 0.6% significantly maximized (65.21 and 68.55 kg) yield per plant against the minimum of 56.75 and 59.50 kg per plant noted under control. Marketable yield was improved to the tune of 14.90 and 15.21% respectively over control. The beneficial role of boron may be assigned to its optimal level which might have played important role in flowering and fruiting processes, nitrogen metabolism, hormone synthesis and cell division (Russel 1957) [20]. It helped would have also in mobilization of food material to the fruits thereby increasing the yield of healthy fruits. The findings are in accordance with the reports of Kumar *et al.,* (2009) [13], Banyal and Rangra (2011) [4] and Kumar *et al.,* (2016) [14-16] in litchi. Interactive treatments of NAA×boron did not touch level of significance in all above attributes during both the years barring marketable yield per plant during first year and N_2 B_2 gave significantly maximum 74.64 kg yield per plant and the minimum of it was obtained under N_0 B_0 (45.82 kg).

Table 1: effect of foliar spray of NAA and boron on flowering, fruiting and fruit retention in litchi

Days to flowering (Days)

	2017-18					2018-19				
Treatments	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**
Control	27.17	25.26	25.16	25.60	25.80	25.41	23.31	23.19	23.07	23.75
NAA 30 ppm	24.31	24.04	23.80	23.86	24.00	22.13	21.98	21.60	21.71	21.86
NAA 60 ppm	23.71	24.16	22.60	23.21	23.42	22.30	22.20	21.02	21.39	21.73
NAA 90 ppm	24.48	23.81	23.08	23.15	23.63	22.85	21.97	22.72	21.78	22.33
Mean	24.92	24.32	23.66	23.96		23.17	22.37	22.13	21.99	
	N	B	N×B					N	B	N×B
C.D.	0.867	0.867	N.S.					0.709	0.709	N.S.
S.E. (d)	0.426	0.426	0.851					0.348	0.348	0.696

Length of panicle (cm)

	2017-18					2018-19				
Treatments	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**
Control	27.86	29.23	31.30	31.85	30.06	29.72	31.09	33.10	33.65	31.89
NAA 30 ppm	29.01	30.78	32.90	33.41	31.53	31.12	32.62	34.70	35.21	33.41
NAA 60 ppm	30.26	32.86	34.96	34.44	33.13	32.18	34.61	36.80	36.53	35.03
NAA 90 ppm	29.72	32.38	34.51	33.95	32.64	31.82	34.26	36.41	35.88	34.59
Mean	29.21	31.31	33.42	33.41		31.21	33.15	35.25	35.32	
	N	B	N×B					N	B	N×B
C.D.	1.011	1.011	N.S.					1.397	1.397	N.S.
S.E. (d)	0.496	0.496	0.992					0.686	0.686	1.372

Number of fruits at pea stage

	2017-18					2018-19				
Treatments	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**
Control	35.41	37.26	37.89	37.93	37.12	38.36	40.10	40.92	40.98	40.09
NAA 30 ppm	40.00	42.08	42.13	42.81	41.76	43.18	45.22	45.38	45.78	44.89
NAA 60 ppm	42.60	43.80	45.95	45.70	44.51	45.56	46.54	49.07	48.82	47.50
NAA 90 ppm	42.07	42.43	42.65	42.17	42.33	45.22	45.66	45.78	45.39	45.51
Mean	40.02	41.39	42.16	42.15		43.08	44.38	45.29	45.24	
	N	B	N×B					N	B	N×B
C.D.	1.125	1.125	N.S.					1.322	1.322	N.S.
S.E. (d)	0.552	0.552	1.104					0.649	0.649	1.298

Number of fruits at maturity stage

	2017-18					2018-19				
Treatments	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**
Control	17.58	19.88	20.25	20.39	19.52	18.96	21.12	21.78	21.96	20.95
NAA 30 ppm	21.85	22.60	22.70	22.84	22.50	23.31	24.26	24.41	24.61	24.15
NAA 60 ppm	22.85	23.30	24.56	24.41	23.78	24.66	24.98	26.12	25.98	25.43
NAA 90 ppm	22.49	22.70	22.94	22.86	22.75	24.17	24.44	24.73	24.62	24.49
Mean	21.19	22.12	22.61	22.62		22.77	23.70	24.26	24.29	
	N	B	N×B					N	B	N×B
C.D.	0.744	0.744	N.S.					0.824	0.824	N.S.
S.E. (d)	0.365	0.365	0.731					0.404	0.404	0.808

Table 2: Effect of foliar spray of NAA and boron on size, weight and yield of litchi

Fruit length (cm)

	2017-18					2018-19				
Treatments	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**
Control	2.50	2.64	2.83	2.84	2.70	2.71	2.86	3.05	3.06	2.92
NAA 30 ppm	2.60	2.75	2.90	2.94	2.80	2.83	2.98	3.15	3.28	3.06
NAA 60 ppm	2.72	2.90	3.36	3.28	3.06	2.96	3.12	3.52	3.45	3.26
NAA 90 ppm	2.68	2.88	3.26	3.24	3.01	2.92	3.04	3.42	3.39	3.19
Mean	2.62	2.79	3.09	3.07		2.85	3.00	3.28	3.29	
	N	B	N×B					N	B	N×B
C.D.	0.270	0.270	N.S.					0.152	0.152	N.S.
S.E. (d)	0.133	0.133	0.265					0.075	0.075	0.149

Fruit diameter (cm)

	2017-18					2018-19				
Treatments	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**
Control	2.25	2.43	2.48	2.50	2.41	2.41	2.56	2.62	2.64	2.56
NAA 30 ppm	2.54	2.62	2.74	2.79	2.67	2.70	2.78	2.87	2.92	2.82
NAA 60 ppm	2.56	2.82	3.05	2.92	2.84	2.71	2.96	3.18	3.06	2.98
NAA 90 ppm	2.55	2.70	2.90	2.88	2.76	2.70	2.86	3.03	3.01	2.90
Mean	2.47	2.64	2.79	2.77		2.63	2.79	2.92	2.91	
	N	B	N×B					N	B	N×B
C.D.	0.239	0.239	N.S.					0.085	0.085	N.S.
S.E. (d)	0.117	0.117	0.235					0.042	0.042	0.084

Fruit weight (g)

	2017-18					2018-19				
Treatments	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**
Control	16.85	17.30	18.22	18.40	17.69	18.07	18.42	18.78	19.01	18.57
NAA 30 ppm	17.10	17.90	19.15	19.20	18.34	18.72	19.07	20.17	20.24	19.55
NAA 60 ppm	17.86	18.90	19.80	19.60	19.04	18.88	20.08	20.85	20.59	20.10
NAA 90 ppm	17.69	18.70	19.70	19.45	18.88	18.63	19.72	20.51	20.34	19.80
Mean	17.37	18.20	19.22	19.16		18.57	19.32	20.08	20.04	
	N	B	N×B					N	B	N×B
C.D.	0.593	0.593	N.S.					0.638	0.638	N.S.
S.E. (d)	0.291	0.291	0.582					0.313	0.313	0.627

Marketable yield per plant (kg)

	2017-18					2018-19				
Treatments	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**	**B_0**	**B_1 (0.2%)**	**B_2 (0.4%)**	**B_3 (0.6%)**	**Mean**
Control	45.82	47.90	49.61	50.91	48.56	48.18	50.28	53.03	54.12	51.40
NAA 30 ppm	58.80	61.17	65.16	69.86	63.74	61.66	64.62	68.72	72.68	66.92
NAA 60 ppm	60.96	71.36	74.64	73.15	70.03	63.85	74.53	78.14	77.07	73.40
NAA 90 ppm	61.42	66.76	68.26	66.94	65.84	64.33	69.86	72.12	70.32	69.16
Mean	56.75	61.80	64.42	65.21		59.50	64.82	68.00	68.55	
	N	B	N×B					N	B	N×B
C.D.	2.250	2.250	4.500					2.325	2.325	N.S.
S.E. (d)	1.104	1.104	2.209					1.141	1.141	2.282

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