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Studies on the Effect of Naa, 4-Cpa and Boron on Growth and Yield of Green Chilli (Capsicum Annuum L.) Var. Lam 353 in Summer

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Abstract—*During summer months, there is a drastic reduction in plant growth, fruit set and yield in chilli due to high temperatures. In chilli, high temperatures during day time (above 300C), coupled with warm nights (above 170C), causes abscission of flowers and poor fruit set there by reducing the yield considerably. Warm winds cause drying of stigma and high temperatures reduces pollen viability and stigma receptivity. Plant growth regulators and micronutrients have profound effect on growth and yield of summer chilli. Hence, the present investigation entitled "Studies on the effect of NAA, 4-CPA and boron on growth and yield of green chilli (Capsicum annuum L.) Var. Lam 353 in summer" was carried out during summer, 2013 at Horticultural College and Research Institute, Dr. Y. S. R. Horticultural University, Venkataramannagudem, West Godavari District, Andhra Pradesh. The studies were carried out with 16 different treatments involving two growth regulators (NAA and 4-CPA) and micronutrient boron individually and in combinations, at two different concentrations sprayed at 60, 90, 120, 150 and 180 DAS. The experiment was laid out in a randomized block design (RBD) with three replications. With regard to growth characters, the plants sprayed with 20 ppm NAA + 0.05% boron (T9) recorded maximum plant height (83.33 cm), maximum plant spread (137.33 cm), maximum number of primary branches (17.0) and minimum number of days to 50% flowering (63 days) compared to other treatments. Similarly, the plants sprayed with 20 ppm NAA + 0.05% boron also recorded the highest fruit set percentage (30.33%), maximum number of fruits per plant (124), fruit girth (2.98 cm) and mean fruit weight (2.24 g). The highest green chilli yield per plant (263.5 g) with an estimated yield of 145.9 q/ ha was observed in the plants sprayed with 20 ppm NAA + 0.05% boron (T9). It was followed by the treatment 20 ppm NAA (T2) with 260.3 g/ plant and 141.69 q/ ha respectively and were found on par with each other and significantly superior to control. While in the control, it was 128.4 g per plant with an estimated yield of 70.98 quintals per hectare. The highest benefit : cost ratio (4.29) was obtained with combination of 20 ppm NAA + 0.05% boron (T9), followed by 20 ppm NAA (T2) with 4.21.*

Keywords*: Green chilli, NAA, 4 – CPA, Boron,Growth and yield.*

1. INTRODUCTION

Chilli (*Capsicum annuum* L.) is an important vegetable cum spice crop belongs to the family Solanaceae. It is the most important commercial crop of India. India is the largest exporter of chilli in the world. India exports chilli to USA, UK, Russia, Canada, Italy, Netherlands, Singapore, Saudi Arabia, UAE and Germany in the form of dry pods, chilli powder and oleoresins. The growth promoters like NAA and 4CPA enhance the source-sink relationship and hormone modified translocation of photosynthates, which will help in better retention of flowers and fruits and seed filling at the later stages of crop growth. There is great potential to increase the yield levels in chilli either by reducing the flower drop or by increasing the fruit set. Micronutrients are required in minute quantities by the plants. The micronutrients are often needed in quantities greater than the soil can supply, so they should be supplemented through foliar application to enhance the yield. Boron plays an important role in the pollination process of plants, reproductive organs are particularly rich in boron. Adequate boron supply is essential for proper nucleic acid metabolism and influences the incorporation of phosphorus into RNA and DNA. (Dongre *et al.,* 2001, Basavarajeswari *et al.,* 2008). During summer months, there is a drastic reduction in plant growth, fruit set and yield in tomato, brinjal and chilli due to high temperatures. In case of chilli, high temperatures during day time (above 30^0C), coupled with warm nights (above 17^0C), causes abscission of flowers and poor fruit set there by reducing the yield considerably. Warm winds cause drying of stigma and high temperatures reduces pollen viability and stigma receptivity. Plant growth regulators and micronutrients have profound effect on growth and yield of summer chilli. The present study is initiated to study the effect of Boron and growth regulators (NAA & 4CPA) individually and in combinations on growth and yield of chilli variety Lam 353 in summer months.

2. MATERIAL AND METHODS

The seeds were directly sown in main field with a spacing of 60 cm between rows and 30 cm within the row and the field was irrigated immediately after sowing. Healthy seeds of chilli were dibbled at five seeds per hill and all the recommended cultural practices were followed during the crop period. The experiment was laid out in a randomized block design (RBD) with three replications and the experiment consists of 16 different treatments involving two growth regulators (NAA and 4CPA) and micronutrient boron individually and in combinations, at two different concentrations sprayed at 60, 90, 120, 150 and 180 DAS. The details of all the treatments are furnished below: T_1: NAA 10 ppm; T_2: NAA 20 ppm; T_3: 4CPA 25 ppm; T_4: 4CPA 50 ppm; T_5: Boron 0.05%; T_6: Boron 0.1%; T_7: NAA 10 ppm + Boron 0.05%; T_8: NAA 10 ppm + Boron 0.1%; T_9: NAA 20 ppm + Boron 0.05% ; T_{10}: NAA 20 ppm + Boron 0.1%; T_{11}: 4CPA 25 ppm + Boron 0.05% ; T_{12}: 4CPA 25 ppm + Boron 0.1%; T_{13}: 4CPA 50 ppm + Boron 0.05% ; T_{14}: 4CPA 50 ppm + Boron 0.1% ; T_{15}: Control (water spray); T_{16}: Absolute control (without water spray).

3. GROWTH PARAMETERS

3.1 Plant height (cm) at 60, 90, 120 DAS and at final harvest :

The data on growth parameters i.e. plant height as influenced by NAA, 4CPA and boron application at various growth stages as presented in Table 1. The maximum plant height was recorded by the plants sprayed with 20 ppm NAA + 0.05% boron (T_9) with 41.20 cm, 54.40 cm, 64.03 cm and 83.33 cm at 60, 90 and 120 DAS and at final harvest respectively, followed by plants sprayed with 20 ppm NAA + 0.1% boron (T_{10}) with 40.73 cm, 54.17 cm, 62.77 cm and 82.67 cm. Minimum plant height was recorded with absolute control (T_{16}) with 29.40 cm, 44.87 cm, 55.30 cm and 71.33 cm respectively Increased plant height might be due to apical dominance effect of auxins, cell elongation, elongation of shoot and more photosynthetic activity. Similar findings were reported by Maurya and Lal (1987); Yamger and Desai (1987); Doddamani (1988); Revanappa (1993); Singh and Lal (1994); Balaraj (1999); Bhalekar *et al.* (2009) in chilli; Pal *et al.* (1970) in okra and Abdullah and EI-Rahimo (1982) in field bean.

3.2 Plant spread (cm) at 60, 90, 120 DAS and at final harvest :

The highest plant spread at 60, 90, 120 DAS and final harvest was recorded (Table 1) by the plants sprayed with 20 ppm NAA + 0.05% boron (T_9) with 87.40 cm, 107.60 cm, 125. 73 cm and 137.33 cm respectively closely followed by 20 ppm NAA (T_2) with 87.07 cm, 105.20 cm, 124.00 cm and 136.33 cm respectively. Higher temperatures in summer months, might have acted as limiting factor in shoot growth and development of chilli. Increased plant spread in NAA, 4- CPA and boron applications might be due to increased cell divisions in the shoot, improved translocation of photosynthates and this might have resulted in increasing shoot growth. This was also in confirmation with the results reported by Doddamani and Panchal (1989); Rao *et al.* (1990); Revanappa (1993); Singh and Lal (1994); Kore *et al.* (2003); Wahida *et al.* (2004) and Bhalekar *et al.* (2009) in chilli.

3.3 Number of primary branches at 60, 90, 120 DAS and at final harvest:

Maximum number of primary branches at all stages were recorded (Table 1) by the plants sprayed with 20 ppm NAA + 0.05% boron (T_9) with 9.43, 10.93, 11.37 and 17.0 respectively, followed by plants treated with 20 ppm NAA (T_2) with 8.87, 10.87, 11.30 and 16.30 respectively. Minimum number of primary branches per plant were recorded with controls (T_{15} and T_{16}) at all the growth stages. The cumulative effect of NAA and boron increased the number of primary branches which might be due to stimulation of cell divisions in the cambium, more efficient photosynthetic activity and accelerated horizontal growth resulted in highest number of lateral shoots per plant. These results are in accordance with earlier reports by Bhalekar *et al.* (2009) in summer chilli and Arvindkumar *et al*. (2012) in bitter gourd by the application of NAA and boron combinations.

4. YIELD AND YIELD COMPONENTS

4.1 Days to 50 per cent flowering:

Days to 50 per cent flowering was significantly influenced by plant growth regulators and micronutrient treatments as present in Table 2. The plants sprayed with combination of 20 ppm NAA + 0.05% boron (T_9) recorded the lowest number of days to 50% flowering (63 days), followed by (T_2) 20 ppm NAA (65.67 days), 10 ppm NAA (T_1) and combination of 20 ppm NAA + 0.1% boron (T_{10}), which were on par with one another and significantly superior to controls (T_{15} and T_{16}), which took 76 and 77.67 days respectively. The growth regulator might have influenced the physiological regulation of flower formation of the plant possibly influencing the timing of anthesis mechanism (Das and Prusty, 1969). Day (2000) reported that optimum supply of boron stimulated the uptake of phosphorus by plant roots and might have promoted more flower clusters formation, as phosphorus directly promotes flowering.

4.2 Fruit set per cent (%):

Highest fruit set per cent was recorded (Table 2) in plants sprayed with 20 ppm NAA + 0.05% boron (T_9) with 30.33%, followed by 20 ppm NAA (T_2) with 28.33% and combination of 20 ppm NAA + 0.1% boron (T_{10}) with 27.00%, which were on par with one another and significantly superior to controls. Minimum fruit set percentage observed in controls ($T_{15a}$and

T_{16}) with 18.67% and 17.33% respectively. Fruit set is defined as the transition of a quiescent ovary to a rapidly growing young fruit. Chilli fruit set is very sensitive to environmental conditions, in particular, to too low or high temperatures that affect pollen development and anther dehiscence. Fruit set depends on the successful completion of pollination and fertilization (Gillaspy *et al*., 1993). The climate in Venkataramannagudem is hot humid summer and mild winters and temperature in summer exceeds 40^{o}C. The failure of fruit set at high temperatures could be attributed to abscission of flowers, drying of stigma, reduced pollen viability and stigma receptivity. Further, it may also be attributed to reduction of carbon export from the leaf and inability of reproductive organs to import assimilates in the early stages of flower development. High temperature reduces fruit set, fruit production and yield in chilli. The harsh climate, especially extremely high temperature in summer reduce normal vegetative and reproductive organs development for proper fruit setting and maturation in chilli. Plant growth regulators NAA and 4 CPA had positive effect on fruit set, which might be due to increase in auxin levels there by decreasing ABA levels in reproductive organs. NAA had an important effect on the fruit retention of several vegetables as well as horticulture crops and thus increasing yield subsequently (Younis and Tigini, 1977; Naqvi *et al*. 1998). It is established fact that boron plays an important role in flowering and fruit formation (Nonnecke, 1989) by maintaining cell integrity, improving respiration, enhancing metabolic activities and uptake of nutrients.

4.3 Days to first picking:

Minimum number of days to first picking (103 days) was recorded (Table 2) by the plants sprayed with 20 ppm NAA + 0.05% boron (T_9) followed by 20 ppm NAA (T_2) with 104.67 days and 10 ppm NAA (T_1) with 105.67 days. Control (T_{16}) took maximum number of days (112.67 days) to first picking. The reason for early harvesting may be due to early transition of vegetative phase to flowering phase, which causes early flower induction and fruit set. Similar results were reported by Chaudhary *et al.* (2006) and Bhalekar *et al.* (2009) in summer chilli.

4.4 Number of fruits per plant:

Significantly higher number of fruits (124 fruits) were recorded (Table 2) by the plants sprayed with combination of 20 ppm NAA + 0.05% boron (T_9), followed by 20 ppm NAA (T_2) with 121 fruits and combination of 20 ppm NAA + 0.1% boron (T_{10}) with 116.3 fruits and were found, on par with one another and significantly superior to controls (T_{15} and T_{16}) which recorded 95.7 and 90.4 fruits respectively. The increased number of fruits per plant may be due to treated plants remained physiologically more active, resulting in more number of flowers and fruit set per cent. . Similar results were found in some research works Bhalekar *et al.* (2009) in summer chilli; Arvindkumar *et al*. (2012) in bitter gourd and Saptari and Dewi (2013) in chilli.

4.5 Number of seeds per fruit:

The plants sprayed with combination of 20 ppm NAA + 0.05% boron (T_9) recorded (Table 3) the highest seed number (66.73), followed by 20 ppm NAA (T_2) with 63.53 seeds and 20 ppm NAA + 0.1% boron (T_{10}) treatments. Controls (T_{15} and T_{16}) were recorded minimum number of seeds per fruit (T_{15} and T_{16}) with 53 and 49.60 respectively. The growth promoters like NAA and 4CPA enhance the source-sink relationship and hormone modified translocation of photosynthates, which will help in better retention of flowers, fruits and seed filling at later stages of crop growth. The results are in agreement with the finding of Bhalekar *et al.* (2009) in summer chilli and Saptari and Dewi (2013) in chilli.

4.6 Average fruit weight (g):

Significant difference were observed among the treatments on average fruit weight as presented in Table 3. Among the treatments plants sprayed with 20 ppm NAA + 0.05% boron (T_9) recorded maximum fruit weight (2.24 g) and it is on par with 20 ppm NAA (T_2) treatment with 2.17 g. Lowest average fruit weight was recorded in control (T_{15} and T_{16}) i.e 1.39 g and 1.36 g respectively. The increase in fruit weight in the plants sprayed with NAA might be due to built up of adequate food stock for developing more bigger sized fruits (Ravanappa, 1993).

4.7 Test weight (g):

Among the treatments, combination of 20 ppm NAA + 0.05% boron (T_9) recorded (Table 3) the highest test weight (2.25 g), followed by 20 ppm NAA (T_2) with 2.24 g and 20 ppm NAA + 0.1% boron (T_{10}) with 2.19 g. All the treatments recorded higher test weight than controls (1.42 and 1.27 g). Increase in test weight by application of NAA 20 ppm was also reported by Balaraj (1999). This might be due to increased fruit weight and better seed filling in later stages of crop growth when compared to untreated treatments. Increase in test weight by application of NAA 20 ppm was also reported by Balaraj (1999).

4.8 Green chilli yield per plant (g):

The data on the fruit yield per plant indicated that all the plant growth regulators and micronutrient treatments recorded higher yield compared to controls as recorded in Table 3. Among the treatments, plants sprayed with combination of 20 ppm NAA + 0.05% boron (T_9) recorded the highest fruit yield per plant (263.5 g), followed by 20 ppm NAA (T_2) with 260.3 g and were found on par with each other and significantly superior to controls (T_{15} and T_{16}) with 135.3 g and 128.4 g respectively. Combination of NAA and boron application showed cumulative effect on fruit yield per plant which may

be attributed to higher fruit set, more number of fruits per plant and more fruit weight recorded in the present study. Boron was needed by the crop plants for cell division, nucleic acid synthesis, uptake of calcium and transport of carbohydrates (Bose and Tripathi, 1996) which resulted in increase of fruit yield.

4.9 Estimated green chilli yield per hectare (q):

The application of plant growth regulators and micronutrient boron showed a profound influence on green chilli yield per hectare (q) as presented in Table 3. Wide variation was observed among the treatments and it varied from 70.98 q/ ha to145.90 q/ ha. It indicated significant difference among the treatments. Maximum green chilli yield per hectare (145.9 q/ ha) was recorded by the plants sprayed with combination of 20 ppm NAA + 0.05% boron (T_9) followed by 20 ppm NAA (T_2) with 141.69 q/ha and were found on par with each other and all the treatments recorded higher values than controls (T_{15} and T_{16}), which recorded 74.55 q/ ha and 70.98 q/ha respectively. Increased yield by application of growth regulators (NAA and 4 CPA) might be due to appropriate growth of plants, control of abscission layer in full bloom stage and acceleration in fruit development by the positive hormonal actions. Similar results were also obtained by Balaraj (1999) and Revanappa (1993) by application of 20 ppm NAA in chilli. Increased yield due to application of NAA with boron had been reported by Bhalekar *et al.* (2009) in summer chilli. Combined application of NAA and boron resulted not only increase in fruit set but also increased the chilli yield in summer. Thus, hormone application have resulted in significantly increase in chilli fruit set which have obviously resulted in significant increase in chilli yield per hectare.

5. FUTURE LINE OF WORK:

In the present study, by using growth regulators and micronutrients in summer chilli in smaller areas gave positive results hence paved way for future experimentation on chilli in larger areas, if the same results are found to be proved in larger areas, this base line can be practically implemented at farmers level to fetch commercial yield in chilli during off-season.

Table 1: Effect of growth regulators and micronutrient boron on plant height (cm) plant spread and number of primary branches at 60, 90, 120 DAS and at final harvest in summer chilli Var. Lam 353.

Treatments	Plan height (cm)				Plant spread (cm)				Number of primary branches (No.)			
	60days	90days	120days	At final harvest	60days	90days	120days	At final harvest	60days	90days	120days	At final harvest
T_1 : NAA 10 ppm	35.67	50.23	59.40	78.67	69.90	92.13	109.07	117.33	8.07	9.47	10.20	15.0
T_2 : NAA 20 ppm	37.27	50.50	59.87	81.67	87.07	105.20	124.00	136.33	8.87	10.87	11.30	16.3
T_3 : 4CPA 25 ppm	36.60	52.70	62.20	81.33	76.27	91.13	110.20	120.67	6.90	9.23	9.57	14.0
T_4 : 4CPA 50 ppm	32.67	48.23	57.30	75.33	78.13	102.47	115.73	129.33	7.70	9.57	10.83	16.3
T_5 : Boron 0.05%	33.60	46.57	57.43	76.00	75.40	84.87	111.00	121.33	6.77	9.87	10.00	14.3
T_6 : Boron 0.1%	34.73	49.67	59.27	80.67	76.33	99.93	122.20	135.00	7.03	10.57	10.60	15.0
T_7 : NAA 10 ppm + Boron 0.05%	32.40	48.03	57.57	76.00	75.73	86.87	108.73	119.00	7.30	10.23	10.57	15.3
T_8 : NAA 10 ppm + Boron 0.1%	33.93	47.47	55.40	74.33	71.00	88.93	104.80	115.33	7.33	8.73	9.13	14.0
T_9 : NAA 20 ppm + Boron 0.05%	41.20	54.40	64.03	83.33	87.40	107.60	125.73	137.33	9.43	10.93	11.37	17.0
T_{10} : NAA 20 ppm + Boron 0.1%	40.73	54.17	62.77	82.67	85.73	100.87	120.80	129.00	8.43	10.70	10.83	16.3
T_{11} : 4CPA 25 ppm + Boron 0.05%	37.37	52.47	61.30	81.67	79.20	101.07	121.20	132.33	7.63	10.57	10.73	15.3
T_{12} : 4CPA 25 ppm + Boron 0.1%	38.33	52.83	61.93	82.00	74.27	100.20	119.27	134.33	7.80	10.13	10.83	14.3
T_{13} : 4CPA 50 ppm + Boron 0.05%	39.40	52.40	61.27	81.00	81.60	95.27	111.67	128.33	7.87	9.73	10.03	15.7
T_{14} : 4CPA 50 ppm + Boron 0.1%	35.53	51.27	61.33	81.67	83.13	102.80	115.07	126.33	8.50	10.70	11.00	15.7
T_{15} : Control (water spray)	30.87	45.13	60.00	72.33	68.53	91.93	103.27	113.33	6.70	8.47	8.90	13.3
T_{16} : Absolute control (without water spray)	29.40	44.87	55.30	71.33	67.33	91.87	101.33	109.00	6.20	8.20	8.80	12.7
C.D.	NS	NS	NS	NS	9.65	11.32	15.32	11.92	NS	NS	NS	NS
SE(d)	3.69	3.83	4.23	3.94	4.70	5.52	7.46	5.81	0.97	0.97	0.85	2.33
C.V.	12.68	9.37	8.67	6.13	7.45	7.01	8.01	5.68	15.47	12.02	10.06	18.95

Table 2: Effect of growth regulators and micronutrient boron on Days to 50% flowering, Fruit set per centage, Days to first picking, number of fruits per plant, fruit length (cm) and fruit girth (cm) in summer chilli Var. Lam 353.

Treatments	Days to 50% flowering	Fruit set per centage	Days to first picking	Number of fruits per plant
T_1 : NAA 10 ppm	66.67	25.00	105.67	113.7
T_2 : NAA 20 ppm	65.67	28.33	104.67	121.0
T_3 : 4CPA 25 ppm	72.00	21.33	107.67	105.0
T_4 : 4CPA 50 ppm	71.67	24.67	109.67	108.7
T_5 : Boron 0.05%	73.67	21.33	108.00	98.3
T_6 : Boron 0.1%	72.00	22.00	107.67	102.3
T_7 : NAA 10 ppm + Boron 0.05%	69.67	23.33	106.67	101.9
T_8 : NAA 10 ppm + Boron 0.1%	67.00	24.33	107.00	108.1
T_9 : NAA 20 ppm + Boron 0.05%	63.00	30.33	103.00	124.0
T_{10} : NAA 20 ppm + Boron 0.1%	66.67	27.00	106.67	116.3
T_{11} : 4CPA 25 ppm + Boron 0.05%	73.67	21.33	108.67	107.1
T_{12} : 4CPA 25 ppm + Boron 0.1%	72.33	23.00	108.00	104.7
T_{13} : 4CPA 50 ppm + Boron 0.05%	71.33	22.33	109.67	97.3
T_{14} : 4CPA 50 ppm + Boron 0.1%	71.00	24.00	108.33	103.0
T_{15} : Control (water spray)	76.00	18.67	110.00	95.7
T_{16} : Absolute control (without water spray)	77.67	17.33	112.67	90.4
C.D.	5.43	5.27	NS	13.84
SE(d)	2.65	2.57	2.81	6.74
C.V.	4.59	13.43	3.20	7.78

Table 3: Effect of growth regulators and micronutrient boron on average fruit weight (g), number of seeds per fruit, test weight (g) green chilli yield per plant (g), green chilli yield per hectare (q) and ascorbic acid in summer chilli Var.Lam353.

Treatments	Average fruit weight (g)	Number of seeds per fruit	Test weight (g)	Green chilli yield per plant (g)	Green chilli yield per ha (q)
T_1 : NAA 10 ppm	1.42	61.40	2.07	165.0	89.90
T_2 : NAA 20 ppm	2.17	63.53	2.24	260.3	141.69
T_3 : 4CPA 25 ppm	1.42	56.87	1.51	142.3	77.17
T_4 : 4CPA 50 ppm	1.43	58.13	1.89	157.3	86.67
T_5 : Boron 0.05%	1.54	54.67	1.58	143.5	75.75
T_6 : Boron 0.1%	1.56	55.33	1.92	155.5	84.63
T_7 : NAA 10 ppm + Boron 0.05%	1.47	56.67	1.77	149.6	80.66
T_8 : NAA 10 ppm + Boron 0.1%	1.54	58.67	1.85	150.1	81.86
T_9 : NAA 20 ppm + Boron 0.05%	2.24	66.73	2.25	263.5	145.90
T_{10} : NAA 20 ppm + Boron 0.1%	1.68	62.13	2.19	173.5	93.00
T_{11} : 4CPA 25 ppm + Boron 0.05%	1.49	56.60	1.86	150.3	82.55
T_{12} : 4CPA 25 ppm + Boron 0.1%	1.60	56.87	1.65	164.5	90.68
T_{13} : 4CPA 50 ppm + Boron 0.05%	1.61	57.93	1.99	151.3	85.02
T_{14} : 4CPA 50 ppm + Boron 0.1%	1.49	58.67	2.01	147.5	81.77
T_{15} : Control (water spray)	1.39	53.00	1.42	135.3	74.55
T_{16} : Absolute control (without water spray)	1.36	49.60	1.27	128.4	70.98
C.D.	0.29	NS	NS	33.81	18.32
SE(d)	0.14	4.41	0.29	16.48	8.83
C.V.	10.69	9.45	19.39	12.24	12.12

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