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Evaluation of chilli (*Capsicum annuum* L.) genotypes and their interaction with foliar application of NAA during spring summer season under foot hills of Himalayas in Uttarakhand

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ABSTRACT : An experiment involving twenty four genotypes of chilli and three created environments (E_0 – No spray, E_1 – Single spray on NAA @ 40 ppm and E_2 – Double spray of NAA @ 40 ppm) was carried out during spring summer season at Vegetable Research Centre, Pantnagar to determine the best genotype, suitable environment and their interactions for higher production of chilli. Out of the three environments, E_2 was found better for red ripen fruit yield, number of fruits/plant, 100-seed weight, seed : husk ratio, minimum incidence of disease *viz.*, anthracnose and leaf curl virus, whereas, significant variations were observed for all the 18 characters studied. Among genotypes *viz.*, G_{23} (PC-2062), G_{24} (PC-2064) and G_{22} (PC-2057) produced significantly more number of fruits/plant and G_{20} (PC-7) followed by G_{21} (PC-56) and G_2 (Co-4) performed better for weight of fruits/plant. Genotypes G_{23} and G_{21} produced 110.26 and 71.60 per cent higher yield over check variety Pant C-1, respectively. Longest fruits (13.59 cm) were obtained in G_{20} (PC-7) .More number and weight of seeds/fruit were recorded in G_{22} (PC-2057). Out of all the 72 interactions, $G_{23}E_1$ was found better for number and weight of fruits/plant whereas, $G_{23}E_1$ (254.42 q/ha), $G_{22}E_1$ and G_2E_2 produced higher red ripen fruit yield over rest of the interactions.

KEY WORDS : Chilli, Foliar application, NAA

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Chilli (*Capsicum annuum* L.) is very important spice and condiment crop grown in many states of India for local consumption and export. In chilli, a large number of genotypes are available for cultivation but all are varying in different characters such as plant type, fruit size ranging from 0.5 cm to 30 cm, foliage colour, flower colour, fruit colour at green as well as red ripen stages and their performance is also different from season to season and environment to environment; due to genetic constitution of the genotypes. All the genotypes show variable performance in different environments. The efforts are continuously being made by the researchers to develop high yielding cultivars for growers. However, the productivity of these cultivars is not only determined by their inherent genetic yield potential but is also predominantly influenced by different agro-climatic conditions, environment and management practices. In order to further enhance the productivity of chilli varieties per unit area of land per unit of time, the application of plant growth regulating substances has been found beneficial. Scientists have established that all the plants synthesize minute quantities of different

phytohormones in their body and the endogenous levels of these has direct influence on the yield of any crop.

PGRs at lower concentration act as a promoter but at higher concentrations act as inhibitor. In order to further enhance the productivity of chilli cultivars per unit area of land per unit of time, the application of plant growth regulating substances has been found beneficial. The regulating substances can be applied to modify assimilative activities, growth and developmental functions and to intensify the effects of environmental variables.These chemicals are helpful in checking the problem of flower and fruit drop and thereby increasing the yield. But the optimum concentrations of PGRs suggested by different workers is variable ranging from as low as 1 ppm to as high as 1000 ppm. Keeping in view, the effect of one of the important PGR *i.e.* NAA was studied to improve plant characteristics and present investigation was under taken to find out the best genotype, environment and their interaction for growth, yield and yield attributes in chilli.

RESEARCH METHODS

The experiment was conducted involving twenty four genotypes of chilli and Pant Chilli-1 as standard check with three created environments (E_0-No spray, E_1-Single spray on NAA @ 40 ppm and E_2-Double spray of NAA @ 40 ppm) during spring summer season at Vegetable Research Centre. For study of interaction with genotypes, NAA was applied as foliar spray at two stages of plant growth.

– 1st spray was done at flower bud initiation stage *i.e.* 40 days after transplanting in E_1 and E_2 environments.

– 2nd spray was done at 20 days after 1st spray in only E_2 environment.

– No spray was done in Eo environment.

The climate of Pantnagar is humid sub tropical with minimum and maximum temperature ranging between 4^0C to 25.8^0C and 17.7^0C to 43^0C. The summers are humid, dry and hot whereas winters are cool. Occasionally light rains occur during winter season also. Sometimes frost may occur occasionally. The soil texture of the experimental site was sandy loam. The experiment was laid out in Factorial Randomized Block Design with three replications having 72 plots with unit plot size of 4.50 m^2 accommodating 18 plants /treatment/replication with the spacing of 50cm from row to row and 50cm plant to plant. The data on growth, yield and yield attributes were observed. All cultural and pest control measures were done as and when needed.

RESEARCH FINDINGS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Effect of genotypes :

Among the twenty-four genotypes evaluated, significant variation was observed for various vegetative and reproductive characters. The present study revealed that out of twenty-four genotypes, three genotypes namely, G_{22}, G_{23} and G_{24} gave more number of fruits per plant than check variety Pant-C-1. It might be because of genetic constituent of the genotype and better environment they received for high setting of the fruits as well as more number of short styled flowers. The more number of seeds per fruit were recorded in G_{22} (PC 2057) followed by G_{11} (DLC-352) and G_7 (F_{112}-$_5$-$_{83}$). Higher seed weight per fruit was recorded in G_{22} (PC-2057) and G_{11} and G_7. Seed: husk ratio was found minimum in G_6 (1:1.01) followed by PC-2062 (1:1.10) and PC-2057 (1:1.26).Higher seed weight was recorded EC 519625 followed by PCPGR 2057, whereas higher seed weight per 100g of fruits was reported in Pant C-1 (1:0.90). This might be due to longer and fleshy nature of the fruits which have hollowness and thick pericarp of the fruits. These genotypes may be suitable for chilli powder preparation as also reported by Singh *et al.* (2004). Fruit yield per plant is usually an important index for selecting genotypes with high yield potential per unit area basis which determine their commercial value. The mean fruit yield/plant and per hectare were found higher in G_{23} (184.72 q/ha) followed by G_2 (180.84) and G_{20} (178.77) (Table 2). This might be possible due to their better plant growth, better adaptability to the environment and comparatively larger and thicker fruits which assimilated greater quantum of photosynthates resulting into higher yield potential. These genotypes also had relatively more biological yield.

Effect of environment :

Among the three environments, E_2 produced significantly higher results for ten characters namely plant height, stem diameter, fresh and dry weight of roots/ plant, number of fruits/plant, stalk length, ripen fruit yield, 100 seed weight, seed:husk ratio and minimum incidence of Anthracnose and LCV (%). Under environment E_2 (double spray of NAA @ 40ppm) the above ten

characters such as plant height, stem diameter, fresh and dry weight of roots/plant, performed better because they get congenial conditions, therefore the plants become more vigorous and also produce more number of fruits/plant as well as their weight/plant, 100 seed weight and low incidence of anthracnose and LCV (%).Ultimately all these characters contributed to increase the total yield of fruits/plant as well as per hectare. E_1 influenced ten characters out of twenty *viz*., primary branches/plant, fresh and dry weight of shoots/plant, weight of fruits/plant, fruit length and periphery, biological yield, number and weight of seeds/fruit, TSS and percentage of short-styled flowers. Significant increase was recorded in the above characters with single spray of NAA @ 40ppm (environment E_1). Under environment E_1, plants get the beneficial environment for the development processes, therefore the number of primary branches, fresh and dry weight of shoots/plant, weight of fruits/plant and fruit length and fruit periphery and percentage of short-styled flowers got the ideal conditions for their growth and development..The characteristics under E_2 (twelve characters) and E_1 (eleven characters) marginally differed, therefore both environments are beneficial to produce greater yield as compared to E_0 (no spray). Depending upon the choice of the growers for seed production purpose single spray will be beneficial while for total fruit yield double spray may be useful.

Table 1 : Effect of genotypes, environments and interactions on number of fruits/plant and weight of fruits/plant (g) in chilli

Sr. No.	Genotype	Number of fruits/plant				Weight of fruits/plant (g)			
		E_0	E_1	E_2	Mean	E_0	E_1	E_2	Mean
1.	SKAU-101 (G_1)	61.16	91.83	149.66	100.88	218.83	239.16	360.83	272.94
2.	CO-4 (G_2)	57.83	125.50	94.00	92.44	317.17	519.16	509.16	448.66
3.	KCS-2013 (G_3)	71.83	108.33	103.16	94.44	230.00	317.33	300.00	331.33
4.	BC-40-2 (G_4)	12.33	14.33	18.00	14.88	21.66	22.50	54.33	32.83
5.	BC-25 (G_5)	104.33	117.16	121.00	114.66	368.66	407.50	470.83	415.55
6.	PC-1 (check) (G_6)	82.33	95.83	153.66	110.33	219.16	286.33	401.16	302.55
7.	$F_{112\text{-}5\text{-}83}$ (G_7)	48.33	99.00	58.16	68.50	75.85	275.00	121.66	157.50
8.	LCA-206 (G_8)	100.50	128.33	139.33	122.72	177.33	216.66	207.50	200.50
9.	JCA-283 (G_9)	45.83	69.16	73.00	62.66	80.83	172.50	192.50	148.61
10.	LCA-353 (G_{10})	90.50	110.83	104.50	101.94	136.66	206.66	164.50	169.27
11.	DLC-352 (G_{11})	90.16	93.16	144.66	109.33	269.00	314.16	426.66	336.61
12.	DLC-324 (G_{12})	104.83	86.50	157.33	116.22	292.50	312.50	363.3	322.77
13.	DLC-1 (G_{13})	27.66	64.33	34.16	42.05	48.00	171.50	73.00	97.50
14.	DLC-2 (G_{14})	57.16	96.66	120.66	91.50	148.33	180.00	212.00	180.11
15.	PC-6 (G_{15})	96.50	85.16	111.66	97.77	285.33	348.00	353.33	328.88
16.	Indra chilli (G_{16})	76.50	119.66	106.50	100.88	185.50	247.50	221.33	218.11
17.	AJEET-3 (G_{17})	58.00	65.83	115.83	79.88	125.66	140.83	188.33	151.60
18.	HSHP-1111 (G_{18})	78.83	93.50	80.00	84.11	250.16	353.33	274.16	292.55
19.	HSHP-154 (G_{19})	85.33	68.16	70.16	74.56	219.16	333.33	300.66	284.38
20.	PC-7 (G_{20})	87.33	90.83	91.83	90.00	444.16	449.16	457.50	450.27
21.	PC-56 (G_{21})	94.66	105.50	96.50	98.88	424.16	453.50	473.33	450.16
22.	PC-2057 (G_{22})	94.83	166.66	114.63	125.22	221.66	497.66	315.83	345.66
23.	PC-2062 (G_{23})	121.50	180.83	150.00	150.22	287.66	635.66	460.83	461.44
24.	PC-2064 (G_{24})	137.83	173.50	146.83	146.05	345.83	459.00	438.33	414.22
	MEAN	77.75	102.10	106.46	95.44	224.71	314.95	304.87	281.85
	C.D. (P=0.05) (E)	4.49				C.D. (P=0.05) (E)		10.52	
	C.D. (P=0.05) (G)	12.71				C.D. (P=0.05) (G)		29.78	
	C.D. (P=0.05) (G x E)	22.02				C.D. (P=0.05) (G x E)		51.58	
	CV %	14.42				CV %		11.27	

Effect of genotype x environment interaction:

Phenotype is the result of interplay of genotype and integrated effect of physical, chemical and biological factors that surround the individual or population that constitute its environment. The variation arising from the lack of correspondence between genetic and non-genetic effects is due to the genotype and environment interaction. Among the seventy two interactions, significant effect was observed for all the vegetative and reproductive characters except one *i.e.* numbers of seed/ fruits, in which interaction effect was found non-significant. The comparison of G x E interaction by means of twenty one characters and twenty four genotypes were made. The mean values for number of fruits/plant among the interactions ranged from 12.33 to 108.33 and $G_{23}E_1$ (180.83) followed by $G_{24}E_1$ and $G_{22}E1$. Weight of fruits/plant was highest in $G_{23}E_1$ (635.66g) followed by G_2E_1 (519.16 g) and G_2E_2 (509.16 g) as compared to rest of the interactions (Table 1). The above results are in accordance with the findings of Khurana *et al.* (2004). Improvement in all the vegetative characters which led to increase in fruits length, width, number and weight fruit/plants may be due to the accumulated result of good genetic constitution and effect of plant growth regulators which provided suitable conditions for growth and developments, better adaptability to the environment, leading to assimilation of greater photosynthates resulting in higher yield

Table 2 : Effect of genotypes, environments and interactions on fruit length (cm) and red ripen fruit yield (q/ha) in chilli

Sr. No.	Genotype	Fruit length (cm)				Red ripen fruit yield(q/ha)			
		E_0	E_1	E_2	Mean	E_0	E_1	E_2	Mean
1.	SKAU-101 (G_1)	7.80	8.18	8.20	8.06	87.50	95.66	146.00	109.72
2.	CO-4 (G_2)	13.23	14.02	13.53	13.34	128.00	207.63	206.66	180.84
3.	KCS-2013 (G_3)	10.20	10.21	11.53	10.64	92.00	127.33	179.00	132.66
4.	BC-40-2 (G_4)	4.05	4.25	4.31	4.26	8.66	9.00	25.20	14.28
5.	BC-25 (G_5)	7.58	8.38	7.90	7.95	128.00	147.33	188.33	154.55
6.	PC-1 (check) (G_6)	5.33	7.91	6.16	6.45	114.84	121.00	160.73	132.33
7.	$F_{112-5-83}$ (G_7)	7.06	8.06	7.30	7.47	30.00	42.00	110.00	60.66
8.	LCA-206 (G_8)	7.96	8.33	8.01	8.10	69.00	86.66	73.50	76.38
9.	JCA-283 (G_9)	6.41	8.15	7.82	7.46	32.33	45.00	101.00	59.44
10.	LCA-353 (G_{10})	7.43	7.98	8.06	7.82	54.88	65.60	83.20	67.86
11.	DLC-352 (G_{11})	4.16	4.23	5.06	4.48	107.60	125.60	169.33	134.20
12.	DLC-324 (G_{12})	7.20	8.18	7.89	7.75	111.66	117.00	149.33	126.00
13.	DLC-1 (G_{13})	4.32	4.56	5.04	4.64	25.86	29.20	55.20	36.75
14.	DLC-2 (G_{14})	5.46	4.81	4.75	5.05	59.33	72.00	86.80	72.71
15.	PC-6 (G_{15})	8.46	9.47	8.67	8.87	114.00	134.33	139.20	129.17
16.	Indra chilli (G_{16})	5.32	5.72	5.58	5.54	74.33	99.00	91.86	88.39
17.	AJEET-3 (G_{17})	6.16	6.59	6.28	6.34	29.86	42.46	54.86	42.40
18.	HSHP-1111 (G_{18})	6.10	6.16	6.37	6.21	109.66	141.30	100.33	117.11
19.	HSHP-154 (G_{19})	6.80	6.97	7.40	7.05	82.86	120.16	123.00	108.61
20.	PC-7 (G_{20})	13.06	14.20	13.57	13.89	175.66	182.66	177.66	178.77
21	PC-56 (G_{21})	7.64	9.25	8.26	8.39	169.66	179.80	192.66	180.60
22.	PC-2057 (G_{22})	10.22	10.81	10.66	10.57	88.66	199.06	126.33	138.02
23.	PC-2062 (G_{23})	8.59	8.61	8.66	8.62	115.66	254.42	184.33	184.72
24.	PC-2064 (G_{24})	7.67	7.84	8.26	7.93	139.33	184.66	176.77	166.88
	Mean	7.42	8.06	7.88	7.79	89.55	117.86	129.91	112.21
	C.D. (P=0.05) (E)	0.17				C.D. (P=0.05) (E)		7.48	
	C.D. (P=0.05) (G)	0.50				C.D. (P=0.05) (G)		21.16	
	C.D. (P=0.05) (G x E)	0.87				C.D. (P=0.05) (G x E)		36.65	
	CV %	6.97				CV %		20.24	

potential.

Yield being the outcome of many characters was significantly influenced by improvement of other characters. The interaction, *viz.*, $G_{23}E_1$ followed by G_2E_1 and G_2E_2 were found superior having 254.42q/ha, 207.63 q/ha and 206.66 q/ha yield, respectively (Table 2). The interaction $G_{22}E_1$ was found superior for number and weight of seeds per fruit with means values of 60.47 and 334.43 mg, respectively (Table 3). Comparison of genotypes within each environment revealed that G_6E_2 (587.3 mg) followed by $G_{22}E_1$ (586.0 mg) and $G_{24}E_1$ (553.66 mg) gave superior results for 100 seed weight whereas $G_{18}E_2$ followed $G_{18}E_1$ and $G_{16}E_1$ with means values 1:5.08, 1:4.65 and 1:4.06 gave better results for seed: husk ratio. Similar work related to the present investigation was also carried out by Arora *et al.* (2014); Jabeen *et al.* (2011); Deepa Devi and Shanthi (2013); Kivadasannavar *et al.* (2012) and Padma and Sivasubramaniam (2013).

Conclusion :

On the basis of above studies it may be concluded that out of three environments, E_2 (double spray of NAA @ 40 ppm) and E_1 (single spray of NAA @ 40 ppm) was superior than E_0 whereas among the genotypes, the highest fruit yield was recorded under G_{23} (PC-2062) followed by G_2 (CO-4) and G_{21} (PC-56). Similarly among the interactions, $G_{23}E_1$ followed by $G_{24}E_1$ and $G_{22}E_1$ were

Table 3: Effect of genotypes, environments and interactions on seed weight per 100g of chilli (g) and number of seeds/fruit in chilli

Sr. No.	Genotype	Seed weight /100g chilli				Number of seeds/fruit in chilli			
		E_0	E_1	E_2	Mean	E_0	E_1	E_2	Mean
1.	SKAU-101 (G_1)	4.73	4.80	4.87	4.80	30.86	32.59	35.04	32.83
2.	CO-4 (G_2)	5.15	5.11	5.00	5.09	36.14	40.85	43.81	40.26
3.	KCS-2013 (G_3)	4.34	4.16	4.14	4.21	33.74	45.96	39.96	39.89
4.	BC-40-2 (G_4)	6.11	6.22	6.30	6.21	34.00	39.96	37.20	37.05
5.	BC-25 (G_5)	5.33	5.15	5.07	5.18	35.60	44.06	41.34	40.33
6.	PC-1 (check) (G_6)	9.32	9.22	9.11	9.21	35.47	40.46	42.95	39.63
7.	$F_{112\text{-}5\text{-}83}$ (G_7)	4.86	4.81	4.86	4.84	43.66	46.10	48.66	46.16
8.	LCA-206 (G_8)	5.20	5.11	5.08	5.13	24.96	32.96	28.43	28.78
9.	JCA-283 (G_9)	7.19	7.20	7.08	7.16	31.80	35.10	35.70	34.20
10.	LCA-353 (G_{10})	15.39	15.60	16.16	15.71	32.36	38.20	41.66	37.40
11.	DLC-352 (G_{11})	7.59	7.70	7.88	7.72	46.56	48.43	50.80	48.60
12.	DLC-324 (G_{12})	9.02	9.15	9.21	9.14	40.13	50.10	44.74	45.01
13.	DLC-1 (G_{13})	6.46	6.45	7.07	6.66	34.00	40.40	39.54	37.95
14.	DLC-2 (G_{14})	9.94	10.18	10.66	10.26	31.04	34.53	38.38	34.65
15.	PC-6 (G_{15})	6.48	7.62	7.17	7.09	28.55	39.30	34.92	34.26
16.	Indra chilli (G_{16})	3.55	3.55	3.73	3.61	32.21	33.94	37.53	34.56
17.	AJEET-3 (G_{17})	11.64	12.16	13.32	12.37	25.54	33.10	27.08	28.57
18.	HSHP-1111 (G_{18})	3.54	3.37	3.10	3.34	27.02	34.46	28.84	30.11
19.	HSHP-154 (G_{19})	4.73	4.97	5.22	4.97	33.62	39.81	41.00	38.14
20.	PC-7 (G_{20})	3.36	3.33	3.54	3.41	30.13	34.41	36.42	33.55
21.	PC-56 (G_{21})	7.55	7.63	7.88	7.69	31.06	43.80	33.20	36.02
22.	PC-2057 (G_{22})	8.59	8.63	8.87	8.69	49.36	60.47	51.29	53.56
23.	PC-2062 (G_{23})	8.43	8.63	8.88	8.64	37.90	40.06	39.23	39.05
24.	PC-2064 (G_{24})	9.51	9.58	9.86	9.65	42.10	47.96	46.73	45.59
	Mean	7.00	7.09	7.25	7.11	34.49	40.70	39.35	38.18
	C.D. (P=0.05) (E)	0.80				C.D. (P=0.05) (E)		2.25	
	C.D. (P=0.05) (G)	0.22				C.D. (P=0.05) (G)		6.36	
	C.D. (P=0.05) (G x E)	0.39				C.D. (P=0.05) (G x E)		11.03	
	CV %	3.39				CV %		17.89	

better for number of fruits/plants whereas $G_{23}E_1$, $G_{22}E_1$ and G_2E_2 produced higher red ripen fruit yield (254.42q/ha, 207.63q/ha, 206.66q/ha, respectively) over rest of the interactions.Thus above studies indicated that different genotypes performed differently in different environments and it may be due to their interactions which provided better conditions for their growth and developmental processes.

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