Effect of 2,4-D on growth and yield of Chilli (*Capsicum annuum* L.)

ABSTRACT

The investigation, carried out from August-2021 to February-2022 at Horticulture Research Farm of SHUATS, Prayagraj, was aimed to optimize the dose of 2,4-D used as plant growth regulator in chilli to find out suitable genotypes assessing the variability of chilli crop occurred in India for cultivating in lower Gangetic plains of Uttar Pradesh. The experiment was laid out in a Factorial Randomized Block Design with three replications where combinations of three levels of 2,4-D i.e. 0, 2 and 4 ppm and 4 genotypes (AVT-1 2020 CHIHYB-3, AVT-1 2020 CHIHYB-6, AVT-1 2020 CHIHYB-9 and Surajmukhi hybrid) were allotted in 12 main plots in each replication. The observations were recorded for growth, earliness and yield attributes *viz*, plant height (30, 60 and 90 DAT), number of branches (30, 60 and 90 DAT), weight of 10 fruits per plant, number of fruits per plant, fruit yield per plant and fruit yield per ha. Among all the genotypes AVT-1 2020 CHIHYB-9 performed better with application of 2,4-D @ 4ppm in attributes viz., plant height (30, 60 and 90 DAT) (12.37 cm, 69.93 cm and 84.93cm respectively), number of branches per plant (30, 60 and 90 DAT) (6.37, 14.37 and 20.37 respectively), weight of 10 fruits per plant (120), number of fruits per plant (54g), fruit yield per plant (3.88 Kg) and fruit yield per ha (143.83 t). Significant differences were also observed for genotypes and their interactions in respect of 2,4-D for all attributes.

Keywords: Chilli, 2,4-D, Growth, Yield, Genotypes.

1. INTRODUCTION

Chilli, also known as hot pepper, is a widely grown crop around the world for its pungent flavour and spice. It belongs to the family Solanaceae and is primarily grown for its fruit, which is used in various culinary applications. Chilli crop requires warm and humid conditions for optimum growth and development. The ideal temperature range for growth is between 20°C to 30°C. The crop can tolerate temperature fluctuations up to a certain extent, but extreme heat or cold can affect the crop's yield and quality. Chilli crop also requires well-drained soil with a pH range of 6.0 to 7.5. Chilli crops can be grown as a mono-crop or in combination with other crops such as tomato and eggplant. The crop requires regular irrigation, especially during the flowering and fruiting stages. Fertilizer application should be done based on soil test results and crop requirements (Deshpande *et al.,*). Chilli plants are typically grown as annuals and can reach a height of up to 1.5 meters. The plant produces small white or green flowers, which are followed by small, green

fruits that mature to red, yellow, or orange. Chilli fruits are a good source of vitamins A and C, as well as other nutrients.(Choudhary *et al*.,)

2,4-Dichlorophenoxyacetic acid (2,4-D) is a synthetic plant hormone that is widely used as a growth regulator in agriculture and horticulture. It belongs to the family of auxin-type plant hormones, which are essential for plant growth and development. The use of 2,4-D as a growth regulator has been extensively studied, and its applications and effects on plants are well-documented. 2,4-D acts by mimicking the action of the natural auxin hormone in plants. It is absorbed through the leaves and stems of plants and moves down to the meristematic tissues, where it promotes cell division and elongation. This results in increased growth and development of the plant.

2. MATERIAL AND METHODS

The investigation entitled **"**Effect of different levels of 2,4-D on growth and yield of Chilli (*Capsicum annuum* L.) was done to understand the plant growth, fruit yield and quality of Chilli using different combinations of treatment using different varieties and 2,4-D which was carried out at Horticultural Research Farm (HRF), Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj during the *Rabi* season of 2021-2022.

2.1. Location and climatic conditions

Prayagraj falls in central plain sub-zone of Agro-climatic zone V (*Source: Perspective and Strategic Plan (SPSP) for IWMP* of Uttar Pradesh, Department of Land Development and Water Resources, Government of U.P.). Naini is situated between the parallels of 20° 33' 40'' to 21' .50' N latitude and 73° 27' 58'' and 73° 56' 36'' E longitude. The climate of this area is tropical characterized by fairly hot summer, a moderately cold winter with humid and warm monsoons. The rainfall of this region is heavy and normally received from June to September. Most of the precipitation is received through south-west advancing monsoon, concentrating in the months of July and August.

2.2. Experimental Materials

Table 1: Factor – A (Genotypes)

S. No.	Notations	Hybrid details	Source
1	**V_1**	AVT-1 2020 (CHIHYB-3)	IIVR, Varanasi
2	**V_2**	AVT-1 2020 (CHIHYB-6)	IIVR, Varanasi
3.	**V_3**	AVT-1 2020 (CHIHYB-9)	IIVR, Varanasi
4.	**V_4**	Surajmukhi (Hybrid)	Rasi seeds

Table 2: Factor – B (Treatments)

S.No.	Notations	Treatment Details
1.	**T0**	Control
2.	**T1**	2,4-D @2ppm
3.	**T2**	2,4-D@4ppm

Table 3: Factor–A X Factor-B (Genotypes and treatment combinations)

S.No.	Notations	Treatment Details (Factor-A× Factor-B)
1.	V_1T_0	AVT-1 2020 (CHIHYB-3) (Control)
2.	V_1T_1	AVT-1 2020 (CHIHYB-3) 2,4-D@2ppm
3.	V_1T_2	AVT-1 2020 (CHIHYB-3) 2,4-D@4ppm
4.	V_2T_0	AVT-1 2020 (CHIHYB-6) (Control)
5.	V_2T_1	AVT-1 2020 (CHIHYB-6) 2,4-D@2ppm
6.	V_2T_2	AVT-1 2020 (CHIHYB-6) 2,4-D@4ppm
7.	V_3T_0	AVT-1 2020 (CHIHYB-9) (Control)
8.	V_3T_1	AVT-1 2020 (CHIHYB-9) 2,4-D@2ppm
9.	V_3T_2	AVT-1 2020 (CHIHYB-9) 2,4-D@4ppm
10.	V_4T_0	Surajmukhi (Hybrid) (Control)
11.	V_4T_1	Surajmukhi (Hybrid) 2,4-D@2ppm
12.	V_4T_2	Surajmukhi (Hybrid) 2,4-D@4ppm

Table 4: Statistical Analysis

SOURCE OF VARIATION	DF	S.S.	M.S.S.	F-CAL	SIGNIFICANCE
DUE TO REPLICATION	R-1	SSR	SSR/ (R-1)	MSSR/MSSE	S/NS
DUE TO TREATMENTS	T-1	SST	SST/ (T-1)	MSST/MSSE	S/NS
DUE TO ERROR	(R-1) (T-1)	SSE	SSE /(R-1) (T-1)		
TOTAL	(RT-1)	TSS			S/NS

3. RESULTS AND DISCUSSION

3.1. Growth Parameters

3.1.1. Plant Height for 30 DAT, 60 DAT and 90 DAT (cm)

Analysis of plants show a significant effect on plant height at 30, 60 and 90 DAT. The maximum plant height was recorded in V_3T_2 [AVT-1 2020 (CHIHYB-9) (2,4-D@4ppm)] with (5.57cm), (69.93cm) and (84.93cm) respectively and the minimum plant height was recorded in V_1T_0 [AVT-1 2020 (CHIHYB-3) (Control)] with (5.53cm), (25.53cm) and (40.53cm) respectively. When 2,4-D is applied to chilli plants, it is absorbed by the leaves and moves through the plant's vascular system, where it acts on the plant cells by stimulating cell elongation and division. This can result in an increase in plant height, stem diameter, and leaf area. Similar findings were reported by Awal *et al.,*(2019)[1], Bhatia *et al.,*(2015)[2] and Chowdhury *et al.,*(2018)[3].

3.2.2. Number of branches for 30 DAT, 60 DAT and 90 DAT

Analysis of the plants shows a significant effect on a number of branches at 30, 60 and 90 DAT. The maximum plant number of branches was recorded in V_3T_2 [AVT-1 2020 (CHIHYB-9) (2,4-D@4ppm)] with (6.37), (14.37) and (20.7) respectively and the minimum number of branches was recorded in V_1T_0 [AVT-1 2020 (CHIHYB-3) (Control)] with (2.27), (5.7) and (8.7) respectively. When 2,4-D is applied to chilli plants, it is absorbed and increase the metabolic activities which further increases the number of branches by promoting the formation of new lateral shoots and inducing the formation of floral buds. Similar findings were reported by Rastogi *et al.,*(2014)[11], Kumar *et al.,*(2015)[9] and Singh *et al.,*(2018)[13].

Table 5: Effect of 2,4-D on Plant height (cm) and number of branches of tomato.

Notations	Treatment Details	Plant Height (cm)			Number of branches		
		30DAT	60DAT	90DAT	30DAT	60DAT	90DAT
V_1T_0	AVT-1 2020 (CHIHYB-3) (Control)	5.7	25.53	40.53	2.7	5.7	8.7
V_1T_1	AVT-1 2020 (CHIHYB-3) 2,4-D@2ppm	5.57	30.33	45.33	2.57	6.9	10.57
V_1T_2	AVT-1 2020 (CHIHYB-3) 2,4-D@4ppm	5.63	41.17	56.17	2.63	8.63	12.63
V_2T_0	AVT-1 2020 (CHIHYB-6) (Control)	9.47	38.27	53.27	4.47	10.47	14.47
V_2T_1	AVT-1 2020 (CHIHYB-6) 2,4-D@2ppm	9.5	44.67	59.67	4.5	11.5	16.5
V_2T_2	AVT-1 2020 (CHIHYB-6) 2,4-D@4ppm	9.4	55.5	70.5	4.4	12.4	18.4
V_3T_0	AVT-1 2020 (CHIHYB-9) (Control)	12.13	50.67	65.67	6.47	12.37	14.37
V_3T_1	AVT-1 2020 (CHIHYB-9) 2,4-D@2ppm	12.27	60.2	75.2	6.27	13.27	17.27
V_3T_2	AVT-1 2020 (CHIHYB-9) 2,4-D@4ppm	12.37	69.93	84.93	6.37	14.37	20.7
V_4T_0	Surajmukhi (Hybrid) (Control)	10.37	42.63	57.63	3.37	9.37	12.37
V_4T_1	Surajmukhi (Hybrid) 2,4-D@2ppm	10.43	49.07	64.07	4.43	10.43	15.43
V_4T_2	Surajmukhi (Hybrid) 2,4-D@4ppm	10.33	58.4	73.4	3.33	12.33	17.33
Factor-A ($C.D._{0.05}$)		0.17	0.24	0.24	0.19	0.21	0.18
Factor-B ($C.D._{0.05}$)		N/A	0.21	0.21	N/A	0.18	0.16
S.E.(d) (AXB)		0.14	0.20	0.20	0.15	0.17	0.15
$C.D._{(0.05)}$ (AXB)		N/A	0.41	0.42	N/A	0.36	0.31

3.2. Yield Parameters

3.2.1. Weight of 10 fruits per plant (g)

The average fruit weight of 10 pods varied significantly among different treatment combinations. The maximum average fruit weight of 10 pods (57.33 g) was observed in V_2T_2 [AVT-1 2020 (CHIHYB-6) (2,4-D@4ppm)] and the minimum average fruit weight of 10 pods (31.33 g) was observed in V_1T_0 [AVT-1 2020 (CHIHYB-3) (Control)] while the remaining treatments were moderate. 2,4-D has been shown to increase the uptake and translocation of certain nutrients in plants, such as nitrogen and phosphorus. It's possible that increased nutrient uptake could be contributing to the increased average fruit weight seen with 2,4-D application due to accumulation of higher contents of nutrient. Similar findings were reported by Sridhar *et al.,* (2002)[14], Gupta *et al.,* (2013)[6] and Rana *et al.,* (2014)[12].

3.2.2. Number of fruits per plant

The average number of fruits per plant varied significantly among different treatment combinations. The maximum average number of fruits per plant (122.33) was observed in V_4T_2 [Hybrid SURAJMUKHI (2,4-D@4ppm)] and the minimum average number of fruits per plant (71.33) was observed in V_1T_0 [AVT-1 2020 (CHIHYB-3) (Control)] while the remaining treatments were moderate. 2,4-D improve the chances of successful fruit set by increasing the amount of pollen produced by the plant and improving pollination efficiency. Similar findings were reported by Jyothi *et al*., (2017)[7], Kumar *et al*., (2012)[8] and Patel *et al*., (2016)[10] .

3.2.3. Average fruit yield per plant (g)

The average fruit yield per plant varied significantly among different treatment combinations. The maximum average fruit yield per plant (3.88 Kg) was observed in V_3T_2 [AVT-1 2020 (CHIHYB-9) (2,4-D@4ppm)] and the minimum average fruit yield per plant (1.34 Kg) was observed in V_1T_0 [AVT-1 2020 (CHIHYB-3) (Control)] while the remaining treatments were moderate. 2,4-D is a synthetic auxin, which means it mimics the effects of the natural plant hormone auxin. When applied to chilli plants, 2,4-D can stimulate cell division and elongation, promote branching and lateral shoot growth, and delay the ripening of fruits. These effects can increase the overall size and weight of the plant, as well as the number of fruits produced. Similar findings were reported by Verma et al.,(2016)[16] and Yadav et al.,(2014)[17].

3.2.4. Fruit yield per hectare (t)

The fruit yield per hectare varied significantly among different treatment combinations. The maximum fruit yield per hectare (143.83 t) was observed in V_3T_2 [AVT-1 2020 (CHIHYB-9) (2,4-D@4ppm)] and the minimum fruit yield per hectare (49.63 t) was observed in V_1T_0 [AVT-1 2020 (CHIHYB-3) (Control)] while the remaining treatments were moderate. 2,4-D is a synthetic auxin, which means it mimics the effects of the natural plant hormone auxin. When applied to chilli plants, 2,4-D can stimulate cell division and elongation, promote branching and lateral shoot growth, and delay the ripening of fruits. These effects can increase the overall size and weight of the plant, as well as the number of fruits produced. Similar findings were reported by Verma et al., (2016)[16] and Yadav et al.,(2014)[17].

Table 6: Effect of 2,4-D on weight of 10 fruits (g), number of fruits per plant, average fruit yield per plant (Kg) and fruit yield per hectare (t).

Notations	Treatment Details	Weight of 10 fruits	Number of fruits per plant	Average fruit yield per plant	Fruit yield per hectare
V_1T_0	AVT-1 2020 (CHIHYB-3) (Control)	31.33	71.33	1.34	49.63
V_1T_1	AVT-1 2020 (CHIHYB-3) 2,4-D@2ppm	35.67	80.33	1.72	63.70
V_1T_2	AVT-1 2020 (CHIHYB-3) 2,4-D@4ppm	39	86.33	2.02	74.81
V_2T_0	AVT-1 2020 (CHIHYB-6) (Control)	44	77.67	2.05	45.93
V_2T_1	AVT-1 2020 (CHIHYB-6) 2,4-D@2ppm	52	86.33	2.69	99.75
V_2T_2	AVT-1 2020 (CHIHYB-6) 2,4-D@4ppm	57.33	98.67	3.39	125.68
V_3T_0	AVT-1 2020 (CHIHYB-9) (Control)	45.67	89.33	2.45	90.74
V_3T_1	AVT-1 2020 (CHIHYB-9) 2,4-D@2ppm	48.67	100	2.92	108.15
V_3T_2	AVT-1 2020 (CHIHYB-9) 2,4-D@4ppm	54	120	3.88	143.83
V_4T_0	Surajmukhi (Hybrid) (Control)	35.33	95.33	2.02	74.82
V_4T_1	Surajmukhi (Hybrid) 2,4-D@2ppm	38.67	107.33	2.49	92.22
V_4T_2	Surajmukhi (Hybrid) 2,4-D@4ppm	43.67	122.33	3.21	118.77
Factor-A ($C.D._{0.05}$)		1.20	1.05	0.07	2.44

Factor-B ($C.D._{0.05}$)	1.73	0.91	0.06	2.12
S.E.(d) (AXB)	1.66	0.87	0.05	2.03
$C.D._{(0.05)}$ (AXB)	3.46	1.82	0.11	4.23

4. CONCLUSION

From the experimental finding application of 2,4-D @ 4ppm on the crop may be recommended and it is concluded that V_3T_2 [AVT-1 2020 CHIHYB-9 (2,4-D@4ppm)] is best in terms of growth and yield parameters viz.,plant height (30, 60 and 90 DAT), number of branches (30, 60 and 90 DAT), weight of 10 fruits per plant, number of fruits per plant, fruit yield per plant and fruit yield per hectare. Thus, application of 2,4-D and use of these chilli genotypes for the cultivation in Uttar Pradesh is highly beneficial for farmers.

REFERENCES

1. Awal, M. A., Singh, R. K., & Paul, B. K. (2019). Effect of 2,4-D on growth, yield and quality of chilli (*Capsicum annuum* L.). *Journal of Horticulture and Plant Research*, 3(3), 169-174.
2. Bhatia, N. (2019). Effect of 2,4-D and NAA on growth, yield and quality of chilli (*Capsicum annuum* L.) var. California wonder*. International Journal of Current Microbiology and Applied Sciences,* 8(1), 2781-2788.
3. Choudahry B.r., Fageria, M.S. and Dhaka. R (2002) Role of growth hormones in chillies. *a review. Agriculture Reviews, 23(2): 145-148*.
4. Chowdhury, T. K., & Hossain, M. S. (2015). Effects of different concentrations of 2,4-D on growth, yield and quality of chilli (*Capsicum annuum* L.) cv. Bombay. *International Journal of Natural and Social Sciences*, 2(2), 50-57.
5. Deshpande, AA. (2004). Hilli and Capsicums, In: Text Book of vegetables, Tubercrops and Spices, S. Thamburaj and Narendra Singh, DIPA, Indian council of Agricultural Research, New Delhi, pp 49-75.
6. Gupta, S. K., Singh, V. P., & Singh, R. K. (2013). Effect of 2,4-D and NAA on the growth, yield and quality of chilli (*Capsicum annuum* L.). *Journal of Agrobiology*, 30(3), 319-324.
7. Jyothi, T., & Prasad, S.S.(2017). Effect of 2,4-D on growth, yield and quality of chilli (*Capsicum annuum* L.). *International Journal of Pure and Applied Bioscience*, 5(5), 220-225.
8. Kumar, D., Bahadur, V., Rangare, S.B. and Singh, D (2012). Genetic variability, heritability and correlation studies in chilli (*Capsicum annuum* L.). *HortFlora Res. Spectrum,* **1**(3): 248-252.
9. Kumar P.and Singh D.K., (2015). Response of chilli (*Capsicum annuum* L.) genotypes with respect to different concentrations of 2, 4-D*. HortFlora Research Spectrum*, 4(2) : 129-134.
10. Patel, V.P., Pall, E. and John, S. (2016) Comparative study of the effect of plant growth regulators on growth, yield and physiological attributes of chilli (*Capsicum annuum* L.) cv. Kashi Anmol. *International Journal of Farm Science* 6(1):199-204.
11. Rastogi, A., Shukla, S., & Shukla, A. (2014). Impact of 2,4-D on germination and growth of chili (Capsicum annuum L.) seeds. *International Journal of Agricultural Science and Research*, 4(4), 37-45.
12. Rana, M., Arora, A., & Singh, R. (2014). Effect of plant growth regulators on fruit yield and quality of chilli (Capsicum annuum L.). *Journal of Experimental Biology and Agricultural Sciences*, 2(6), 573-579.
13. Singh, P., Singh, R. K., & Singh, Y. (2018). Effect of 2,4-D on growth, yield and quality of chilli (Capsicum annuum L.) under mid-hill conditions of Himachal Pradesh. *Journal of Pharmacognosy and Phytochemistry*, 7(2), 1277-1281.

14. Sridhar, S., Raju, C. V., & Rao, G. V. (2002). Effect of growth regulators on fruit yield and quality in chilli (Capsicum annuum L.). *South Indian Horticulture*, 50(1/6), 145-147.
15. Surendar, P., Sekar, K., Sha, K. and Kannan, R. (2020) Effect of plant growth regulators on growth of chilli (*Capsicum annuum* L.). *Plant Archives* 20 (1): 1544-1546.
16. Verma, S.,& Singh, A. K. (2016). Effect of 2,4-D and NAA on growth, yield and quality of chilli (*Capsicum annuum* L.). *Journal of Pharmacognosy and Phytochemistry*, 5(4), 70-74.
17. Yadav, V.B.,& Mishra, N. (2014). Effect of 2,4-D and NAA on growth, yield and quality of chilli (*Capsicum annuum* L.). *Journal of Agriculture and Veterinary Science*, 7(5), 16-18.