



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

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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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 CHIHBY-3, AVT-1 2020 CHIHBY-6, AVT-1 2020 CHIHBY-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 CHIHBY-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.

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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 [1-4]. 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 [5]. 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 [6]. 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. MATERIALS AND METHODS

The investigation entitled “Effect of different levels of 2,4-D on growth and yield of Chilli (*Capsicum annum* 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

The detailed experimental analysis and statistical analysis procedure have been depicted in Tables 1-4.

Table 1. Factor – A (Genotypes)

S. No.	Notations	Hybrid details	Source
1	V ₁	AVT-1 2020 (CHIHBY-3)	IIVR, Varanasi
2	V ₂	AVT-1 2020 (CHIHBY-6)	IIVR, Varanasi
3.	V ₃	AVT-1 2020 (CHIHBY-9)	IIVR, Varanasi
4.	V ₄	Surajmukhi (Hybrid)	Rasi seeds

Table 2. Factor – B (Treatments)

S. No.	Notations	Treatment Details
1.	T ₀	Control
2.	T ₁	2,4-D @2ppm
3.	T ₂	2,4-D@4ppm

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

S. No.	Notations	Treatment Details (Factor-Ax Factor-B)
1.	V ₁ T ₀	AVT-1 2020 (CHIHBY-3) (Control)
2.	V ₁ T ₁	AVT-1 2020 (CHIHBY-3) 2,4-D@2ppm
3.	V ₁ T ₂	AVT-1 2020 (CHIHBY-3) 2,4-D@4ppm
4.	V ₂ T ₀	AVT-1 2020 (CHIHBY-6) (Control)
5.	V ₂ T ₁	AVT-1 2020 (CHIHBY-6) 2,4-D@2ppm
6.	V ₂ T ₂	AVT-1 2020 (CHIHBY-6) 2,4-D@4ppm
7.	V ₃ T ₀	AVT-1 2020 (CHIHBY-9) (Control)
8.	V ₃ T ₁	AVT-1 2020 (CHIHBY-9) 2,4-D@2ppm
9.	V ₃ T ₂	AVT-1 2020 (CHIHBY-9) 2,4-D@4ppm
10.	V ₄ T ₀	Surajmukhi (Hybrid) (Control)
11.	V ₄ T ₁	Surajmukhi (Hybrid) 2,4-D@2ppm
12.	V ₄ T 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 V₃T₂ [AVT-1 2020 (CHIHBY-9) (2,4-D@4ppm)] with (5.57cm), (69.93cm) and (84.93cm) respectively and the minimum plant height was recorded in V₁T₀ [AVT-1 2020 (CHIHBY-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. [7], Bhatia et al. [8] and Chowdhury et al. [9].

3.1.2 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 V₃T₂ [AVT-1 2020 (CHIHBY-9) (2,4-D@4ppm)] with (6.37), (14.37) and (20.7) respectively and the minimum number of

branches was recorded in V₁T₀ [AVT-1 2020 (CHIHBY-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. [10], Kumar et al. [11] and Singh et al. [2].

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 V₂T₂ [AVT-1 2020 (CHIHBY-6) (2,4-D@4ppm)] and the minimum average fruit weight of 10 pods (31.33 g) was observed in V₁T₀ [AVT-1 2020 (CHIHBY-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. [3], Gupta et al. [12] and Rana et al. [1].

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 ₁ T ₀	AVT-1 2020 (CHIHBY-3) (Control)	5.7	25.53	40.53	2.7	5.7	8.7
V ₁ T ₁	AVT-1 2020 (CHIHBY-3) 2,4-D@2ppm	5.57	30.33	45.33	2.57	6.9	10.57
V ₁ T ₂	AVT-1 2020 (CHIHBY-3) 2,4-D@4ppm	5.63	41.17	56.17	2.63	8.63	12.63
V ₂ T ₀	AVT-1 2020 (CHIHBY-6) (Control)	9.47	38.27	53.27	4.47	10.47	14.47
V ₂ T ₁	AVT-1 2020 (CHIHBY-6) 2,4-D@2ppm	9.5	44.67	59.67	4.5	11.5	16.5
V ₂ T ₂	AVT-1 2020 (CHIHBY-6) 2,4-D@4ppm	9.4	55.5	70.5	4.4	12.4	18.4
V ₃ T ₀	AVT-1 2020 (CHIHBY-9) (Control)	12.13	50.67	65.67	6.47	12.37	14.37
V ₃ T ₁	AVT-1 2020 (CHIHBY-9) 2,4-D@2ppm	12.27	60.2	75.2	6.27	13.27	17.27
V ₃ T ₂	AVT-1 2020 (CHIHBY-9) 2,4-D@4ppm	12.37	69.93	84.93	6.37	14.37	20.7
V ₄ T ₀	Surajmukhi (Hybrid) (Control)	10.37	42.63	57.63	3.37	9.37	12.37
V ₄ T ₁	Surajmukhi (Hybrid) 2,4- D@2ppm	10.43	49.07	64.07	4.43	10.43	15.43
V ₄ T 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

3.2.2 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 V₄T₂ [Hybrid SURAJMUKHI (2,4-D@4ppm)] and the minimum average number of fruits per plant (71.33) was observed in V₁T₀ [AVT-1 2020 (CHIHBY-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. [13], Kumar et al. [14] and Patel et al. [15].

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 V₃T₂ [AVT-1 2020 (CHIHBY-9) (2,4-D@4ppm)] and the

minimum average fruit yield per plant (1.34 Kg) was observed in V₁T₀ [AVT-1 2020 (CHIHBY-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. [16] and Yadav et al. [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 V₃T₂ [AVT-1 2020 (CHIHBY-9) (2,4-D@4ppm)] and the minimum fruit yield per hectare (49.63 t) was observed in V₁T₀ [AVT-1 2020 (CHIHBY-3) (Control)] while the remaining treatments were moderate. 2,4-D is a synthetic auxin, which means it mimics the effects of the

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 ₁ T ₀	AVT-1 2020 (CHIHBYB-3) (Control)	31.33	71.33	1.34	49.63
V ₁ T ₁	AVT-1 2020 (CHIHBYB-3) 2,4-D@2ppm	35.67	80.33	1.72	63.70
V ₁ T ₂	AVT-1 2020 (CHIHBYB-3) 2,4-D@4ppm	39	86.33	2.02	74.81
V ₂ T ₀	AVT-1 2020 (CHIHBYB-6) (Control)	44	77.67	2.05	45.93
V ₂ T ₁	AVT-1 2020 (CHIHBYB-6) 2,4-D@2ppm	52	86.33	2.69	99.75
V ₂ T ₂	AVT-1 2020 (CHIHBYB-6) 2,4-D@4ppm	57.33	98.67	3.39	125.68
V ₃ T ₀	AVT-1 2020 (CHIHBYB-9) (Control)	45.67	89.33	2.45	90.74
V ₃ T ₁	AVT-1 2020 (CHIHBYB-9) 2,4-D@2ppm	48.67	100	2.92	108.15
V ₃ T ₂	AVT-1 2020 (CHIHBYB-9) 2,4-D@4ppm	54	120	3.88	143.83
V ₄ T ₀	Surajmukhi (Hybrid) (Control)	35.33	95.33	2.02	74.82
V ₄ T ₁	Surajmukhi (Hybrid) 2,4-D@2ppm	38.67	107.33	2.49	92.22
V ₄ T 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

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. [16] and Yadav et al. [17].

4. CONCLUSION

From the experimental finding application of 2,4-D @ 4ppm on the crop may be recommended and it is concluded that V₃T₂ [AVT-1 2020 CHIHBYB-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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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