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RESEARCH PAPER

The Effect of Pre-harvest Application of Sodium-Para-Nitrophenolate on Growth, Flowering and Yield Characters of Cucumber (*Cucumis sativus* L.) cv. Swarna Ageti

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ABSTRACT

A field experiment carried out in Vegetable Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India follows a randomized block design with seven treatments and three replications to evaluate the effect of pre-harvest application of Sodium-Para-Nitrophenolate on growth and yield characters of cucumber (*Cucumis sativus* L.) cv. 'Swarna Ageti' during *Kharif* 2019. The treatments including various doses of Sodium-Para-Nitrophenolate i.e. 0.1% SL (T_1), 0.2% SL (T_2), 0.3% SL (T_3), 0.4% SL (T_4), 0.5% SL (T_5) and untreated control (T_7) applied at 30, 45 and 60 days after sowing (DAS) with replications each. The results revealed that the treatment T_5 viz. Sodium-Para-Nitrophenolate 0.5% SL was found to be the most effective treatment, which significantly influenced the number of primary branches per vine, vine length, days to the appearance of first male and female flower, days to 50% flowering, number of male and female flowers per plant, and sex ratio as compared to control. In addition, treatment T5 also increased the yield parameters of cucumber such as fruit length & width, average fruit weight, yield per plot and overall yield.

HIGHLIGHTS

- Cucumber (*Cucumis sativus* L.) is one of the most extensively cultivated and consumed vegetable crops worldwide.
- Different doses of Sodium-Para-Nitrophenolate were applied at 30, 45 and 60 days after sowing on cucumber.
- Sodium-Para-Nitrophenolate 0.5% SL was found to be the most effective treatment as it significantly increases the vegetative, flowering and yield parameters of cucumber.

Keywords: Sodium-Para-Nitrophenolate, yield attributes, plant growth regulator, cucumber, sex ratio

Cucumber (*Cucumis sativus* L.), commonly known as "Khira", belongs to the Cucurbitaceae family, extensively cultivated and consumed vegetable crops throughout the tropical and subtropical parts of the world. It is the second most widely cultivated cucurbit after watermelon (Thapa *et al.* 2020). It probably originated from India and seems to have extended eastwards, subsequently to Europe (De Candolle 1967). Cucumber is cultivated mainly for its fruits which contain calcium, iron, thiamine, niacin and riboflavin, and some natural antioxidants that prevent cardiovascular diseases and cancer (Mukerjee *et al.* 2013, Uthpala *et al.* 2020). Furthermore, it is a rich source of nutrients such as vitamins K and C, pantothenic acid, manganese, beta carotene and phytonutrients like cucurbitacin, lignans and flavonoids (Nayak *et al.* 2017). Cucumber is an herbaceous annual that is

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monoecious in nature, as it produces distinct male and female flowers on the same plant, with axillary actinomorphic flowers that are rarely bisexual. It is a warm-season crop generally grown under both open field and protected conditions, with the optimum temperature of 20° to 30° for its growth and development (Dhakal *et al.* 2019). In India, it is cultivated extensively in the states of West Bengal, Madhya Pradesh, Haryana and Andhra Pradesh (NHB 2021).

Exogenous application of plant growth regulators improves the seed germination, quality of the crop, accumulation of mineral nutrients in plants, increases total yield, protects the plant from pests and is sometimes also used to avoid the loss of yield due to the unfavourable conditions (Mir *et al.* 2019; Dies 2019). They also influence biochemical and physiological parameters like photosynthesis, respiration, protein synthesis, cell extension, and wall thickness and stability (Thapa *et al.* 2011; Pal *et al.* 2016). Sodium-Para-Nitrophenolate (Atonik) is a plant growth regulator that affects various stages of growth and development of plants, boosts endogenous auxin levels, increases nutrient absorption by plant roots and promotes antioxidant and photosynthetic activities of plants (Djanaguiraman *et al.* 2010; Valero *et al.* 2014). It enhances germination and root system of plants, stimulates vegetative growth and development of flower buds, accelerates pollen germination and tube growth; thus, improves flower fertilization and fruit sets, alleviates detrimental effects of stress, the health of crops quality improvement and regulates uptake and accumulation of mineral nutrients in plants and increases yield. It plays a simulative role under optimal conditions and is protective against drought, noble metal stresses and spring frost (Przybysz *et al.* 2014). Considering the importance of Sodium-Para-Nitrophenolate, the present study was therefore planned to explore the potential

MATERIALS AND METHODS

The field experiment was conducted during the *Kharif* season 2019 at the Vegetable Research Farm, Department of Horticulture, Institute of Agriculture Science, Banaras Hindu University, Varanasi, Uttar Pradesh, India. Sowing of the crop was done during the first week of July 2019 using the 'Swarna Ageti' variety in a plot of 3.5 × 3.0 m^2 and 1.5 × 0.6 m^2 as row-to-row and plant-to-plant spacing, respectively. All the intercultural operations, such as weeding, irrigation, and pesticide application, were done as per the recommended package and practices. The experiment was laid out in a randomized block design with seven treatments (Fig. 1) comprising different concentrations of Sodium-Para-Nitrophenolate with three replications each.

Main irrigation channel								
	R_1	T_1	T_2	T_3	T_4	T_5	T_6	T_7
	Sub-irrigation channel							
	R_2	T_3	T_5	T_6	T_2	T_7	T_1	T_4
	Sub-irrigation channel							
	R_3	T_6	T_4	T_1	T_7	T_3	T_5	T_2

Fig. 1: Layout of the experimental field

Foliar application of various doses of Sodium-Para-Nitrophenolate i.e. 0.1% SL (T_1), 0.2% SL (T_2), 0.3% SL (T_3), 0.4% SL (T_4), 0.5% SL (T_5) and untreated control (T_7) were applied at 30, 45 and 60 days after sowing (DAS) at different stage of plant growth with the help of knapsack sprayer fitted with flat fan nozzle. For recording the observations, five vines from each plot were randomly selected and tagged with the labels. Observations on different growth, flowering and yield parameters were recorded from these tagged vines at weekly intervals. The data obtained was analyzed using a computer program SPAR-2 developed by IASRI, New Delhi.

RESULTS AND DISCUSSION

Significant variations in the growth, flowering and yield parameters were observed under the influence of various treatments of Sodium-Para-Nitrophenolate in cucumber.

Morphological Characters

The present investigation showed that the response of Sodium-Para-Nitrophenolate to different morphological characters viz., number of primary branches per vine and vine length (m) were found significant (Table 1).

Number of branches per vine

The number of primary branches per vine significantly increased by the application of Sodium-para-nitrophenolate with the maximum number (6.07) observed in treatment T_5 i.e. Sodium-Para-Nitrophenolate 0.5% SL, which remained at par with T_6 (5.6), T_4 (5.27) and T_4 (5.07). The minimum number of primary branches per vine was recorded in T_7 (control). Increase in the number of primary branches might be due to the application of Sodium-para-nitrophenolate which acts as an anti-mitotic agent, suppressing the apical growth of the main axis and thereby increasing the number of primary branches per vine. Ashvathama *et al.* (2020) also recorded an increase in the number of branches per vine by the application of sodium para nitrophenolate in cucumber.

Vine length (m)

The vine length increased significantly with the increasing doses of Sodium-Para-Nitrophenolate. The treatment T_5 (2.93) was recorded significantly superior to all other treatments, whereas minimum values were observed in treatment T_7 (2.02). Sodium para-nitrophenolate increases the concentration of endogenous auxin, which stimulates plant growth and development by promoting cell division, cell expansion and cell elongation. Similar result was found by Djanaguiraman *et al.* (2005). Increase in the vine length and intermodal length of ridge gourd by the application of different plant growth regulators was also recorded by Hilli *et al.* (2010).

Flowering and sex expression characters

Days to the appearance of first male and female flower

There was reverse response of different treatments on days required for appearance of first male flower (Table 1, Fig. 2). Among all the treatments, the minimum days for the appearance of first male flower (42.00 Days) was noted in treatment T_5 followed by treatment T_6 (43.00 days), T_4 (43.33 days), T_1 and T_2 (44.00 days each) and T_3 (44.33 days). Whereas, the maximum number of days for appearance of first male flower was recorded from treatment T_7 (44.00 Days).

The minimum number of days required to appearance of first female flower was recorded in treatment T_5 (49.00 days) it was found to be most effective followed by T_6 (50.33 days), T_1 (50.67 days), T_3 and T_4 (51.00 days each), all being at par with each other. The maximum days for the appearance of first female flower was noticed in treatment T_7 (53.33 days). The sexual differentiation is controlled by endogenous level of Auxins in regions neighboring the flowering primordia and during flowering the formation of staminate organs may be favored by high level in Auxin in the vicinity of differentiating primordia. Early appearance of both male and

Table 1: Effect of Sodium-Para-Nitrophenolate on growth and flowering parameters of cucumber

Treatment	Dose (g a.i./ha)	Formulation dose (ml/ha)	No. of branches per vine	Vine length (m)	Days to first male flower appear	Days to first female flower appear	Days taken to 50% Female Flowering	Numbers of male flowers per vine	No. of female flowers per vine	Sex ratio (male: female)
T1	0.1 % SL	1ml/L	4.93	2.39	44.00	50.67	55.67	277.80	12.80	21.67
T2	0.2 % SL	2ml/L	5.00	2.41	44.00	52.00	55.00	269.33	13.07	20.67
1T3	0.3 % SL	3ml/L	5.07	2.40	44.33	51.00	56.00	304.07	14.27	21.33
T4	0.4 % SL	4ml/L	5.27	2.43	43.33	51.00	55.67	328.13	14.27	23.00
T5	0.5 % SL	5ml/L	6.07	2.93	42.00	49.00	52.67	283.60	15.73	18.00
T6	0.6 % SL	6ml/L	5.60	2.65	43.00	50.33	54.67	274.47	13.93	19.67
T7 (control)	—	Water spray	3.80	2.02	45.00	53.33	58.33	372.33	12.00	31.00
Mean	—	—	5.10	2.46	43.66	50.04	55.43	301.39	13.72	22.19
SE(d)	—	—	0.48	0.23	0.73	1.08	1.26	18.01	0.50	1.00
SE.m.+	—	—	0.34	0.16	0.51	0.76	0.89	12.74	0.35	0.71
CD (5%)	—	—	1.05	0.49	1.58	2.36	2.75	39.24	1.08	2.18

Legend: *CD– critical difference, SE(d)- standard error of difference, SE.m.- standard error of mean.*

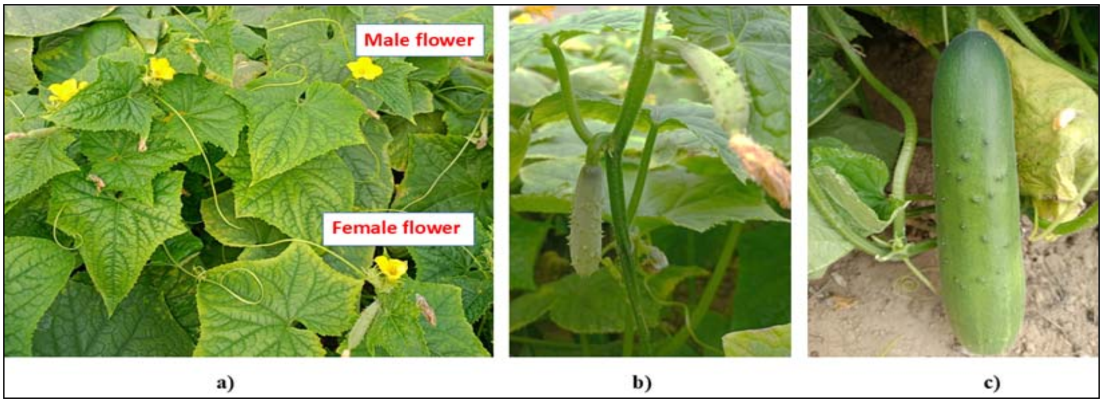

Fig. 2: Effect of Sodium-Para-Nitrophenolate 0.5% SL(T_5) on cucumber; **(a)** male and female flowers, **(b)** fruit development, **(c)** fruit

Table 2: Effect of Sodium-Para-Nitrophenolate on growth and flowering parameters of cucumber

Treatment	Dose (g a.i./ha)	Formulation dose (ml/ha)	Average length of fruit	Average diameter of fruit (cm)	Average fruit weight (g)	Number of fruits per plant	Fruit yield per plot (kg)	Fruit yield (q/ha)
T1	0.1 % SL	1ml/L	13.97	4.65	165.18	6.27	10.33	114.78
T2	0.2 % SL	2ml/L	14.04	4.51	172.01	6.47	10.83	120.30
T3	0.3 % SL	3ml/L	14.26	4.72	176.11	6.53	11.32	125.81
T4	0.4 % SL	4ml/L	14.60	4.76	169.34	6.80	12.52	139.11
T5	0.5 % SL	5ml/L	14.74	4.92	178.12	8.07	13.89	154.37
T6	0.6 % SL	6ml/L	14.69	4.89	175.12	7.20	13.15	146.11
T7 (control)	—	Water spray	13.14	4.20	159.33	5.47	10.12	112.44
Mean	—	—	14.20	4.66	170.74	6.68	11.73	130.41
SE(d)	—	—	0.46	0.20	5.57	0.53	0.56	6.21
SE.m.+	—	—	0.33	0.14	3.94	0.37	0.40	4.39
CD (5%)	—	—	1.01	0.43	12.14	1.15	1.22	13.53

Legend: *CD– critical difference, SE(d)- standard error of difference, SE.m.- standard error of mean.*

female flowers by the application of different growth regulators were also noted by Dongre and Gurjar (2021), Verma *et al.* (1986), Patil *et al.* (1983), Singh and Singh (1984), Singh and Choudhary (1988) and Asghar *et al.* (1990) in cucumber.

Days taken to 50% female flowering

Days required for 50 % female flowering showed a significant variation in relation with different levels of treatments. The lowest days (52.67 days) required for 50 % female flowering was recorded from treatment T_5 which was closely followed by treatment T_6 (54.67 days), T_2 (55.00 days), T_1 and T_4 (55.67 days each), T_3 (56.00 days) and the highest value (58.33 days) required for 50 % female flowering was recorded from T_7-control. Similar results were observed by Dongre and Gurjar (2021), Ashvathama *et al.* (2020) and Mohan *et al.* (2016) in cucumber by the foliar application of different growth regulators.

Number of male and female flowers per vine

The application of Sodium-Para-Nitrophenolate showed significant variation in the number of male and female flowers per plant (Table 1). The minimum number of male flowers per plant (269.33) was produced by treatment T_2, which was followed by T_6 (274.47), T_1 (277.80), T_5 (283.60). Similar observation found from treatment T_3 (304.07) and T_4 (328.13). The treatment T_7-control produced the maximum number of male flowers per plant (372.33). The results indicated that maximum male flower was produced in control comparing with plant growth regulators (Sodium-Para-Nitrophenolate). Sodium-Para-Nitrophenolate significantly reduced the total number of male flowers in present study derived support from the finding of Dongre and Gurjar (2021) and Verma *et al*. (2018).

There was a significant difference among the number of female flowers per plant (Table 1) at the various levels of treatment. The treatment T_5 was recorded most effective as it produced maximum number of female flowers per plant (15.73) followed by T_3 and T_4 (14.27 each), T_6 (13.93), T_2 (13.07) and T_1 (12.80). The minimum number of female flowers per plant (12.00) was recorded in treatment T_7-control. Our result is in line with the findings of Dongre and Gurjar (2021) and Hidayatullah *et al*. (2009) who also recorded an increase in the number of female flowers by the application of growth retardant in cucumber.

Sex ratio (Male: Female)

The results indicated that the effect of different concentrations of Sodium-Para-Nitrophenolate on sex ratio of cucumber differed significantly. All the treatments significantly lowered the male: female sex ratio over T_7-control (Table 1). Among all the treatments, T_5 were found to be most effective in lowering the male: female flower ratio (18.00), which was at par with the treatment T_6 (19.67). Whereas, in the treatment T_7 showed highest ratio (31.00). Growth regulators have tremendous effects on sex expression and flowering in various cucurbits leading to either suppression of male flowers or increasing in the number of female flowers (Mosum and Masri 1999). Similar results regarding sex ratio were also observed by Ashvathama *et al.* (2020) in cucumber.

Yield Characters

Number of fruits per plant

The Sodium-Para-Nitrophenolate significantly affected the number of fruits per plant (Table 2). It was noticed that treatment T_5 produced the maximum yield of fruits per plant (8.07), which was at par with treatment T_6 (7.20). The treatment T_7-control produced the minimum number of fruits per plant (5.47). It could be due to the fact that sodium-para-nitrophenolate promotes the number of female flowers and suppresses the number of male flowers, thereby increasing the number of fruits and producing more yield. The above results are in line with the findings of Mehdi *et al.* (2012) and Nayak *et al.* (2017) who reported that the application of growth retardants significantly influenced the yield parameters such as the number of fruits per plant in cucumber.

Average length and diameter of fruit (cm)

The effect of Sodium-para-nitrophenolate on the average length and diameter of fruits was found to be significant (Table 2). The maximum average length of fruit (14.74 cm) was noted in treatment T_5 (Fig. 2), followed by T_6 (14.69 cm), T_4 (14.60 cm) and T_3 (14.26 cm), with all the treatments being at par with each other. The minimum fruit length (13.14 cm) was recorded in the T_7, which was significantly similar to treatment T_1 (13.97 cm). Similarly, the maximum and minimum fruit diameter was recorded in treatment T_5 (4.92 cm) and T_7 (4.2 cm). The probable reason for the increase in the length and diameter of fruit after the application of Sodium-para-nitrophenolate may be attributed to the higher respiration and photosynthesis in treated plants as compared to control resulting in greater accumulation of carbohydrates, owing to photosynthesis, and overall increased size of fruit. Kakroo *et al.* (2005) and Mohan *et al.* (2016) recorded an increase in the fruit size of bottle gourd and cucumber, respectively by the application of growth regulators.

Average fruit weight (g)

The application of Sodium-Para-Nitrophenolate significantly increased the average fruit weight of cucumber in different treatments. The average fruit weight in different treatments varied between 159.33 and 178.12 g in treatments T_7 and T_5, respectively. Treatment T_5 was found statistically superior to all other treatments, whereas the treatment T_7 was at par with T_1 and T_2. The increase in fruit weight is attributed to the fact that the treated plants remained physiologically more active to build sufficient food material for developing flower and fruits. The results are in close agreement with the findings of Dongre and Gurjar (2021) and Ashvathama et al. (2020) who reported the same in cucumber.

Fruit yield per plot (kg)

The application of Sodium-para-nitrophenolate had significantly increased fruit yield per plant (Table 2). The maximum fruit yield per plot was recorded in treatment T_5 (13.89 kg), followed by T_6 (13.15 kg), both at par to each other. The lowest fruit yield per plot was recorded from treatment T_7 (10.12 kg), which was statistically significant with treatments T_1 (10.33 kg), T_2 (10.83 kg), and T_3 (11.32 kg). Increased fruit yield might be due to the increase in pistillate flower production, which resulted in more fruits per plant.

Fruit yield (q/ha)

Treatment T_5 produced maximum fruit yield (178.67 q/ha), followed by the treatment T_6 (146.11 q/ha), both being at par to each other. It was followed by T_4 (139.11 q/ha), T_3 (125.81 q/ha), T_2 (120.30 q/ha) and T_1 (114.78 q/ha). Whereas, the lowest fruit yield was observed in treatment T_7. The results are in agreement with the findings of Dongre and Gurjar (2021), and Ashvathama *et al.* (2020).

CONCLUSION

The results indicated that the application of various levels of Sodium-Para-Nitrophenolate significantly influenced the morphological, physiological, floral, and yield parameters. Sodium-Para-Nitrophenolate 0.5% SL was found to be most effective as it produced maximum vine length at the time of last harvesting as well as increasing the number of branches per plant, hastens the appearance of the first male and female flowers as compared to control, reduced number of male flowers as well as an increased number of female flowers and resulted in a maximum number of fruits per plant.

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