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Response of plant growth regulator on green pod yield of vegetable cowpea (*Vigna unguiculata* L.)

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Abstract
The present study entitled "Response of plant growth regulator on green pod yield of vegetable cowpea (*Vigna unguiculata* L.)" was conducted during *Rabi* season 2023-24 in the research and instructional farm at Bharregaon under Pt. Kishori Lal Shukla College of Horticulture and Research Station, Rajnandgaon (C.G.). A field study was undertaken in a randomized block design with three replications and thirteen treatments, including a control, to assess the influence of different plant growth regulators on the growth, productivity, and profitability of cowpea. The treatments comprised foliar sprays of Naphthalene Acetic Acid (NAA) at 20, 30 and 40 ppm, Etherel at 150, 250 and 350 ppm, Kinetin at 20, 30 and 40 ppm, and Cycocel at 250, 300 and 350 ppm, applied at 15, 45 and 60 days after sowing. The objective of the investigation was to identify the most effective regulator for enhancing vegetative development, green pod yield, and economic returns in cowpea.
The findings showed marked variations among the treatments. Kinetin @ 40 ppm resulted in the tallest plants (71.03 cm), whereas NAA @ 40 ppm proved most efficient in improving yield traits. This treatment recorded the highest number of branches per plant (7.71), earliest flowering (34 days), maximum pods per plant (23.70), greater pod length (27.28 cm), thicker pod diameter (0.70 cm), heavier pod weight (110.17 g), maximum green pod yield per plot (4892.28 gm), and highest yield per hectare (138.90 q). Moreover, the dry matter content of pods (14.00%) was also superior in this treatment. Importantly, NAA @ 40 ppm achieved the maximum benefit cost ratio (2.21), reflecting its clear economic advantage.

Keywords: Cowpea (*Vigna unguiculata* L.), plant growth regulators, foliar application, vegetative growth, Pod yield, NAA, Etheral, Kinetin, Cycoceol

Introduction
Cowpea (*Vigna unguiculata* L.) is an important warm season legume belongs to family Leguminaceae, grown by many farmers in the semi-arid tropics for human consumption and for feeding animals. It is a self-pollinated crop having chromosome no. 2n= 22, which originated from Africa (Thorat *et al.* 2017) [24]. It is the most important green podded vegetable crop in the world and commonly known as lobia, chauli, and barbatti it is also considered as a miracle crop in the world. Cowpea covers 14 million ha area with over 8 million metric tonnes annual production in all over world. In India, cowpea has occupied an area of 1.34 million ha with a total production of 1.01 million tones. (I.P.R.I. Kanpur). Tamil Nadu is covered maximum area and production of cowpea in India. In Chhattisgarh, total area under cultivation is 15000 ha with 12000 tones production. (Anon, 2022).
The nutrient composition of cowpea seed has protein (24.8%), fat (1.90%), fiber (6.3%), carbohydrates (63.6%). Some minerals are also present such as Calcium, Sodium, Magnesium, Phosphorous and Iron. Cowpea contain high percentage of Vitamins, viz., thiamine (0.00074%), riboflevin (0.00042%) and niacin (0.00281%). Apart from that leguminous vegetables have the ability to fix atmospheric nitrogen through their root nodules which makes the soil fertile. Vegetables are necessary for maintaining human health. (Thorat *et al.* 2017) [24].
Cowpeas are more cosmopolite than other legume vegetables and are grown throughout most of India. They have shown very promising results and hold great promise for making a significant contribution to the breakthrough in pulse production. Cowpeas are grown all over

India for their long green pods, which are used as a vegetable, as well as their seeds, which are used as pulses, and their leaves, which are used as green manure and green fodder.

Plant hormones are the term used to describe naturally occurring (endogenous) growth chemicals, whereas growth regulators are the one used to describe manufactured ones. PGRs have an impact on crop production by influencing physiological processes including as germination, vigour, soil nutrient uptake, photosynthesis, respiration, assimilate partitioning, growth inhibition, defoliation, and post-harvest ripening.(Thorat *et al*.2017) [24].

NAA improves cell elongation and division by encouraging DNA synthesis within the cell, because of increased photosynthesis, respiration and improved CO2 fixation in the plant, it shortened the juvenile phase. NAA promotes root growth, flowering, and fruit set in legumes, foliar application of NAA increases plant height, branch number, and Leaf Area Index. (Murugan *et al*., 2020) [26]. Phototropism, apical development, respiration, and flower bud formation have all been found to be improved by NAA. The main way that NAA works is through its mode of action. the direct effect of components of the cell wall on the plasma membrane's permeability (Choudhary *et al*., 2023) [5].

Material and Method

The experiment was conducted at experimental farm, under Pt. Kishori Lal Shukla College of Horticulture and Research Station, Pendri, Rajnandgaon Chhattisgarh during the year 2023- 2024. The experiment was laid out in Randomized Block Design (RBD) with thirteen treatments and three replications. The treatment includes, T_0 (Control/Water), T_1 (NAA 20 ppm), T_2 (NAA 30 ppm), T_3 (NAA 40 ppm), T_4 (Etheral150 ppm), T_5 (Etheral250 ppm), T_6 (Etheral 350 ppm), T_7 (Kinetin 20 ppm), T_8 (Kinetin 30 ppm), T_9 (Kinetin 40 ppm), T_{10} (Cycoceol 250 ppm), T_{11} (Cycoceol 300 ppm), and T_{12} (Cycoceol 350 ppm). The preparatory tillage was done and flat beds of 1.6 m X 2.2 m plot were prepared and seeds were sown at spacing of 40 X 20 cm. The recommended interculture operations were followed uniformly to experimental plots. The Spraying with different growth regulators was done thrice i.e. 15, 45 and 60 days after transplanting. The observations on growth and yield parameters viz; plant height (cm), number of branches per plant, days to first flowering, no. of green pod per plant, length of green pod per plant(cm), diameter of green pod(cm), weight of green pod(gm), total green pod yield per plant(gm), total green pod yield per plot(kg), total green pod yield per ha(q), benefit cost ratio were recorded and analyzed statistically as procedure described.

Results and Discussion

Plant height (cm)

The data on plant height as impacted by plant growth regulators that were observed at 30. 60 and 90 days after sowing are presented in Table 1. At 30 days, T_9 (Kinetin @ 40 ppm) recorded significantly the highest plant height (27.65 cm) which was statistically at par with treatments T_8 (Kinetin @ 30 ppm) (25.74cm) respectively. However, T_0 (Control) plant height recorded the lowest plant height (18.18cm) among the others. At 60 days, T_9 (Kinetin @ 40 ppm) recorded significantly the highest plant height (57.86 cm) which was statistically at par with treatments T_8 (Kinetin @ 30 ppm) (55.09 cm), while, it was the lowest (47.97cm) in T_0 (Control). At 90 days, T_9 (Kinetin @ 40 ppm) recorded significantly the highest plant height (71.03 cm) which was statistically at par with treatments T_8 (Kinetin @ 30 ppm) (69.97 cm), while, it was the lowest (60.02 cm) in T_0 (Control). Remarkable increase in the plant height at 30, 60 and 90 DAS was observed with Kinetin @ 40 ppm. This might be due to Kinetin induces cell division and increased plant height by promoting cell extension. These results are in conformity with the findings of application of kinetin in cowpea by Hala and Bassiouny (2001) [8], Ullah *et al.* (2007) [25], Thaware *et al.* (2008) [23].

Number of branches per plant

Table 1 shows the findings on the number of branches per plant influenced by plant growth regulators that were observed at 30, 60 and 90 days after sowing. T_4 (NAA @ 40 ppm) showed the higher number of branches at 30 days (4.78), which was statistically at par treatments T_2 (NAA @ 30 ppm) (4.33) and T_4 (Etheral @ 150 ppm) (4.28). Nevertheless, out of all the branches, control had the fewest (2.11). T_4 (NAA @ 40 ppm) showed the higher number of branches at 60 days (6.78), which was statistically at par T_2 (NAA @ 30 ppm) (6.21) and T_4 (Etheral @ 150 ppm) (6.11). Nevertheless, out of all the branches, control had the fewest (4.22). T_4 (NAA @ 40 ppm) showed the higher number of branches at 90 days (7.71), which was statistically at par T_2 (NAA @ 30 ppm) (7.42) and T_4 (Etheral @ 150 ppm) (7.39). Nevertheless, out of all the branches, control had the fewest (6.56).Treatment with NAA may have increased the number of branches because auxin stimulated metabolic activity, which is turn affected the formation of axillary buds. (Patel *et al*., 2011) [16]. Sahu and Verma (2020) [19] in yard long beans and Anitha *et al.* (2006) [1] in horse gram also reported similar findings.

Days to first flowering

Data on mean number of days to first flowering as influenced by the various plant growth regulators are presented in Table 1. The days to first flowering was found significantly different in various treatment. Treatment T_3 (NAA @ 40 ppm) induced early flowering at 34 days, which was statistically similar to T_1 (NAA @ 20 ppm) at 35.67 days, T_2 (NAA @ 30 ppm) at 36.33 days and T_6 (Etheral @ 350ppm) at 40.33 days while the treatment T_0 (control) flowered significantly later at 44.67 days. This acceleration is likely attributed to enhanced nutrient translocation to floral primordia caused by NAA application, thus promoting earlier flowering. These results align with previous findings by Mukhtar & Singh, 2006 [14] in cowpea and Pandey *et al*., 2004 [15] in pea.

No. of green pod per plant

The number of green pods per plant was significantly affected by the application of different growth regulators; the results are summarized in Table 1. The highest average number of green pods per plant was observed in treatment T_3 (NAA @ 40 ppm), yielding 23.70 pods which was statistically at par with treatments T_2 (NAA @ 30 ppm) 22.90 pods, and T_9 (Kinetin @ 40 ppm) 22.40 pods. The lowest count (20.38 pods) occurred in the control treatment T_0. Foliar application of NAA markedly increased the number of pods per plant. This enhancement likely resulted from the applied growth regulator boosting enzymatic

activity and endogenous hormone levels, which enhanced leaf photosynthetic development expanding the canopy, increasing foliage biomass, and improving assimilation rates, thereby promoting pod and cluster formation (Patel *et al.* 2011) [16]. These findings are consistent with reports in cowpea by Thaware *et al*. (2006) [22] and Sati *et al*. (2014) [21].

Length of green pod (cm):

Data on length of green pod are summarized in Table The results show that pod length at successive growth stages in cowpea was significantly influenced by the different plant growth regulator treatments. The findings showed that the longest green pods were observed under treatment T_3 (NAA @ 40 ppm), measuring 27.28 cm which length is statistically at par with treatment T_2 (NAA @ 30 ppm), 26.45 cm and T_{10} (CCC @ 250 ppm), 25.90 cm. In contrast, the shortest pods, at 19.27 cm, were found in the control group (T_0). The increase in length of green pod may be due to cell elongation caused by NAA. The result was supported by Mandal and Sanyal (2004) [12] in French bean.

Diameter of pod (cm)

The impact of foliar application of plant growth regulators on pod diameter is shown in Table 1. A significant effect of plant growth regulator on pod diameter was observed among the treatments. The highest pod diameter 0.70 cm was recorded with treatment T_3 (NAA @ 40ppm) which is statically at par to treatment T_2 (NAA @ 30ppm), 0.68 cm and T_1(NAA @ 20ppm), 0.67 cm. The shortest pod diameter 0.51 cm noted in T_0 control. NAA increases mesocarp cell proliferation and enlargement, leading to thicker pod walls and improved nitrogen uptake which supports robust pod development. Similar findings reported by Choudhary *et al.* (2023) [5] *in pea*, and Parmar *et al.* (2011) [27] in green gram.

Weight of green pod (gm)

The effect of Foliar application of plant growth regulator was observed on weight of green pod presented in Table 1. The application of plant growth regulators significantly influenced the weight of green pods in cowpea. Among the treatments, T_3 (NAA @ 40 ppm) exhibited the highest weight of green pods, recording 110.17 gm, followed by T_2 (NAA @ 30 ppm) with 102.98 gm. In contrast, the control treatment (T_0) recorded the minimum weight of 84.22 gm. NAA application promotes the translocation of assimilates from source (leaves) to sink (pods), influencing cell elongation and cell division and promote fruit set, leading to more pods and potentially heavier pods due to better fruit development, resulting in increased pod weight. These findings are in agreement with previous studies on various crops, which have reported that NAA application can enhance pod weight and yield attributes. For instance, in garden pea, Choudhary *et al*. (2023) [5], and Kumar *et al*. (2020) [9] that NAA treatment resulted in increased pod length and weight due to improved assimilate partitioning.

Total green pod yield per plant (gm)

The data presented in Table 1. A significant effect of plant growth regulator on total green pod yield per plant was observed among the treatments. T_3 (NAA @ 40 ppm) recorded the highest yield 249.26 gm, closely followed by T_2 (NAA @ 30 ppm) with 240.41gm. In contrast, the control treatment (T_0) yielded the lowest 171.61 gm. The application of NAA significantly contributed to maximum pod and yield by promoting cell division and cell elongation, leading to increased pod size and weight. Additionally, NAA improved fruit set and development, resulting in more pods per plant and increased yield. It also reduced flower drop and fruit abortion, as well as an increased number of pods per cluster and clusters per plant ensuring more pods reached maturity and contributed to yield. Furthermore, NAA enhanced the source-sink relationship, promoting the translocation of assimilates from leaves to pods, which supported pod growth and development. Overall, NAA's contributed to its ability to increase pod and yield in cowpea. These findings are consistent with previous research on various legume crops, by Desai and Deore, (1985) [7] in cowpea, Das and Prasad, (2003) [6] in mungbean, Kumar *et al*. (2003) [11] in chickpea, Resmi and Gopalkrishnan, (2004) [18] in yard long bean, and Patil *et al*. (2005) [17], in green gram which have also reported improved yields with NAA application.

Total green pod yield per plot (gm)

The data on total green pod yield per plot (gm) as influenced by plant growth regulators recorded are presented in Table 1. The application of plant growth regulators significantly impacted the total green pod yield per plot in cowpea. Notably, T_3 (NAA @ 40 ppm) recorded the highest yield of 4892.28 gm, closely followed by T_2 (NAA @ 30 ppm) with 4666.46 gm. In contrast, the control treatment yielded the lowest at 3171.52 gm. The increase in yield was mainly due to increased number of branches per plant, no. of cluster per plant and number of pod per plant. These results are in accordance with the findings of application of NAA in cowpea by Resmi and Gopalakrishnan (2004) [18], Thaware *et al.* (2008) [23] and Sarvaiya *et al.* (2021) [20]. in cowpea.

Total green pod yield per ha (q)

The data on total green pod yield per ha (q) influenced by plant growth regulators recorded are presented in Table 1. The highest green pod yield of 138.90q/ha was achieved with T_3 (NAA @ 40 ppm), closely followed by T_2 (NAA @ 30 ppm) with 132.57 q/ha, while the control treatment recorded the minimum yield of 90.10 q/ha. The increase in yield can be attributed to NAA's role in promoting a maximum number of pods per cluster, reducing flower drop, and minimizing fruit abortion. Similar results were also found by Das and Prasad (2003) [6] in mungbean, Kumar *et al.* (2003) [11] in chickpea, Resmi and Gopalkrishnan (2004) [18] in yard long bean, Patil *et al.* (2005) [17] in greengram, Sati *et al*. (2014) [21], Desai and Deore (1985) [7] Sarvaiya *et al.* 2021 [20] and Sahu and Verma (2020) [19] in cowpea.

Benefit cost ratio

The economic viability of the treatments was evaluated based on key parameters such as net income, gross income, and benefit-cost ratio, which are crucial for determining the profitability and acceptability of the treatments among farmers. The economic analysis of cowpea cultivation as influenced by plant growth regulators is presented in Table 1. The economic analysis revealed that T_3 (NAA @ 40 ppm) was the most profitable treatment, with a Benefit-Cost Ratio (B:C) of 2.12, generating a gross income of 276000 Rs and a net income of 187426 Rs. This was closely followed by T_2 (NAA @ 30 ppm), which recorded a B:C ratio of 1.98, with a gross income of 264000 Rs and a net income of 175470 Rs. In contrast, the control treatment (T_0) had the lowest

B:C ratio of 0.94, with a gross income of 171000 Rs and a net income of 82666.

Table 1: Mean performance of Growth and yield attributes of cowpea

Treatments	1			2			3	4	5	6	7	8	9	10	11
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS									
T_0	18.18	47.97	60.02	2.11	4.22	6.56	44.67	20.38	19.27	0.51	84.22	171.61	3171.52	90.10	0.94
T_1	19.00	50.75	62.75	3.99	5.67	6.97	35.67	21.47	25.50	0.67	98.92	225.23	4464.96	126.80	1.85
T_2	20.03	51.32	64.30	4.33	6.21	7.42	36.33	22.90	26.45	0.68	102.98	240.41	4666.46	132.57	1.98
T_3	21.69	52.42	65.26	4.78	6.78	7.71	34.00	23.70	27.28	0.70	110.17	249.26	4892.28	138.90	2.12
T_4	23.64	50.98	61.76	4.28	6.11	7.39	43.00	20.80	23.40	0.58	86.38	179.67	3361.60	95.50	1.15
T_5	22.15	49.63	62.69	3.98	5.22	6.86	41.33	21.30	24.90	0.61	88.18	187.82	3556.72	101.10	1.27
T_6	20.66	49.74	63.54	4.23	5.87	7.21	40.33	21.40	25.41	0.65	89.66	191.87	3689.00	104.80	1.35
T_7	22.34	51.53	68.25	3.89	5.31	7.34	40.67	21.70	22.50	0.57	85.26	185.02	3491.84	99.20	1.13
T_8	25.74	55.09	69.97	3.67	5.18	7.37	41.67	22.10	23.70	0.58	85.43	188.82	3582.42	101.83	1.14
T_9	27.65	57.86	71.03	3.44	5.23	6.94	41.00	22.40	24.10	0.61	88.68	198.65	3822.72	108.60	1.25
T_{10}	20.98	49.63	62.60	2.95	5.00	6.41	39.33	20.57	25.90	0.63	89.56	184.22	3471.52	98.60	1.20
T_{11}	22.43	49.32	61.70	3.12	5.65	6.76	41.00	22.30	25.60	0.62	88.85	198.14	3808.64	108.20	1.41
T_{12}	24.54	48.87	61.31	3.34	5.78	6.93	42.33	21.57	24.30	0.61	86.56	186.38	3524.10	100.10	1.23
SE(m±)	1.02	1.82	3.20	0.22	0.24	0.35	1.43	0.64	0.81	0.02	3.26	6.02	117.41	3.56	
C.D. at 5%	2.98	5.32	9.35	0.63	0.71	1.02	4.19	1.85	2.38	0.05	9.52	17.56	342.69	10.40	
CV	7.96	6.17	8.64	10.16	7.57	8.58	6.19	5.06	7.52	4.40	6.20	5.24	5.34	5.71	

1. Plant Height	4. No of green pod per plant	7. Weight of green pod (gm)	10. Total green pod yield per ha (q)
2. No. of Branches	5. Length of green pod (cm)	8. Total green pod yield per plant (gm)	11. Benefit Cost Ratio
3. Days to first flowering	6. Diameter of green pod (cm)	9. Total green pod yield per plot (gm)	

Conclusion

In light of the present experimental findings summarized above, it may be concluded that the application of plant growth regulators enhanced the plant growth, pods yield and the benefit cost ratio influenced significantly in various plant growth regulator treatments. The study of comparison of various treatments revealed that the application of Kinetin showed the better response with respect to the plant height. NAA Showed the maximum no. of branches per plant, days to first flowering, no. of green pods per plant, length of green pod, diameter of green pod, weight of green pod, total green pod yield per plant, total green pod yield per plot, total green pod yield per ha (138.90 q), dry matter content of pod. The B:C ratio was found highest with T_3 (NAA @ 40 ppm) among all the treatments.

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