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Growth, yield and quality of vegetable cowpea influenced by foliar application of antioxidants, plant nutrients and Naa

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Abstract
The current experiment was conducted to evaluate the influence of foliar application of antioxidants, plant nutrients and NAA on the growth, yield and quality of summer grown vegetable cowpea [*Vigna unguiculata* (L.) Walp.] at College of Horticulture, S. D. Agricultural University, Jagudan, Dist. Mehsana, Gujarat, India. The experiment conducted using Randomized Block Design comprising three replications and twelve treatments. The results of this study revealed that, foliar application of Thiourea @200 ppm exhibited highest plant height (53.45cm, 66.40 cm and 73.47 cm) at 45, 75 days after sowing & final harvest, respectively. Application of NAA at 200 ppm showed better response in morphological traits, particularly in the number of branches per plant (5.47, 8.40, and 8.53) at 45 and 75 days after sowing and at the final harvest, respectively. Foliar application of 200 ppm NAA was found significantly superior in yield and quality parameters *viz.*, pods number per cluster (3.47), clusters per plant (29.27), yield per individual plant (166.75 g), yield per plot (4.01 kg), yield per hectare (123.76 q), seed number per pod (12.60), chlorophyll a (0.69 mg/g), chlorophyll b (0.58mg/g) and total chlorophyll (1.24 mg/g) of pod. While, significantly maximum number of pickings (7.00) was observed with application of 200 ppm ascorbic acid, potassium nitrate @0.6%, NAA @100 ppm and 200 ppm.

Keywords: Antioxidants, cowpea, NAA and plant nutrients

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.] belongs to the Fabaceae family (Ehlers and Hall 1997) [4]. It includes four known subspecies (Panella and Gepts 1992) [11], out of which three are widely cultivated. The growth habits of the plant is upright, semi-upright, or as a climber. It performs well with minimal inputs since its root nodules fix nitrogen from the air. As a result, it considered a best suitable crop for the farmers in intercropping systems.

Nutritionally, cowpea is very rich vegetable in protein (3.50 g), calcium (72.00mg), phosphorus (59.00 mg), iron (2.5mg), carotene (564.00 mg), thiamine (0.07 mg), riboflavin (0.09 mg) and vitamin C (24.00 mg) per 100 g of edible pods (Laleeta *et al.*,2017) [9]. On the basisof dry weight, it contains 23.40% protein, 1.80% fat and 60.30% carbohydrates.

It is an important crop in the semiarid regions acrossAfrica and Asia due to it's tolerance for sandy soil and low rainfall. Cowpea is shallow rooted crop and is grown well under low fertility soil andlow moisture regime conditions prevailing in some Indian states. Nowa day, cultivation of summer vegetable cowpea is increasing in Gujarat, because farmers are getting good market price. But, high temperature during summer affects flowering, fruit setting, and pod quality of cowpea.

Antioxidants, plant nutrients and plant growth regulators plays an important role in saving of plant especially during summer from drastic impact of abiotic stress. Among them, NAA is one of the most widely used synthetic auxin. It is a plant growth regulator used for the purpose of inducing flowering and preventing shedding of flower buds. It stimulates the cell division, cell enlargement and cell elongation in apical region of the plant (Krishnamoorthy, 1981) [8].

Ascorbic acid currently holds a significant position due topossession of antioxidant and cellular reductant properties and its diverse role against environmental stresses. Perhaps, the role of ascorbic acid in mediating tolerance to abiotic stress (e.g. UV, salinity and temperature, etc.)

will lead to a greater research focus in future (Khanet al., 2011) [7].

Silicon (Si) is abeneficial element for higher plants because its deficiency causesvarious abnormalities in the plant. Vegetables require an optimum supply of mineral elements like silicon, its role is quite significant in tackling biotic and abiotic stresses of vegetables. Hence, Si application is recommended as a strategy for the improvement of vegetable crops production. Although, the research about the role of Si in vegetable dicots still lags far behind than cereals (Kaushik and Saini, 2019) [6].

Potassium nitrate may be considered the best option for improving water use and overall plant growth, encourages root development, helps the plant to maintain turgor, influences transpiration and stomatal behavior (Hsiao and Lauchli, 1986) [5]. It provides two macronutrients *viz*., nitrogen and potassium, two essential macronutrients. It strengthens plants, enhances flower and fruit development and improves resistance to environmental stress like drought and cold, and also against pests, diseases etc.

Thiourea plays an important role in plant physiological process and effects the growth, yield and quality of clusterbean (Meena*etal*.,2014) [10]. Thiourea relatively inexpensive compound as compare to other agro-chemicals and available easily. Thiourea contains 36% nitrogen and 42.1% sulphur. The stimulating effect of thiourea in different physiological functions of plants is well known (Wahid *et al*., 2017) [20].

Taking consideration of above facts, present investigation was planned and conducted to examine the influence of foliar application of antioxidants, plant nutrients and NAA on growth, yield and quality of vegetable cowpea [*Vigna unguiculata* (L.) Walp.] during summer season.

Materials and Methods

A field experiment was conducted at College Farm, College of Horticulture, S. D. Agricultural University, Jagudan, Dist. Mehsana, Gujarat, India during summer season of 2020 and 2021. The climate of this zone is typically sub-tropical, characterized by semi-arid conditionhaving warm and humid monsoon, cool and dry winter and quite hot and dry summer. Anand Vegetable Cowpea 1 (AVCP 1) was selected for present study. This variety is known for its bushy compact plant type with dark green foliage having broad leaves; produce creamish white flower and medium-sized tender green pods. It also shows resistance to cowpea mosaic virus.

The experiment was carried out using a Randomized Block Design with twelve treatments, which involved the foliar application of antioxidants, plant nutrients and NAA *viz*., T_1 (Absolute control), T_2 (Water spray), T_3 (Ortho salicylic acid @0.2%), T_4 (Ortho salicylic acid @0.3%), T_5 (Ascorbic acid @100 ppm), T_6 (Ascorbic acid @200 ppm), T_7 (Potassium nitrate @0.4%), T_8 (Potassium nitrate @0.6%), T_9 (NAA @100 ppm), T_{10} (NAA @200 ppm), T_{11} (Thiourea@100 ppm) and T_{12} (Thiourea @200 ppm). The application of antioxidants, plant nutrients and NAA as foliar spray on foliage in aqueous form by using afresh solution of spray at 30, 45 and 60 days after sowing. The entire experimental area was divided into plots each measuring 2.70 m x 2.40 m. There was total 36 plots. The manures and fertilizers were applied uniformly to the experimental plots during land preparation. Observations on different growth, yield and quality parameters were recorded and analysed statistically as per Panse and Sukhatme (1985) [12].

Results and Discussion

Morphological parameters

Influence of different treatments on plant height (cm) at 45, 75 DAS and at final harvestare summarized in Table 1. The data showed that the treatments had a significant effect on plant height at 45 and 75 days after sowing, as well as at the final harvest. Significantly the maximum plant height at 45 days after sowing (53.45 cm), 75 days after sowing (66.40 cm) and at final harvest (73.47 cm) were observed with treatment T_{12} (Thiourea @200 ppm) which was found statistically at par with treatment T_{11} (Thiourea @200ppm) for 45 and 75 days after sowing while, T_{11} (Thiourea @100 ppm), T_{10} (NAA @200 ppm), T_9 (NAA@100ppm) and T_8 (Potassium nitrate @0.6%) at final harvest. It was noticed that plant height showed better results by application of plant growth substances. The stimulatory action of thiourea in various physiological process of plant such as photosynthetic carbon fixation mechanism and hence might have increased canopy photosynthesis.

An inspection of data indicated that the number of branches per plant was significantly influenced by different treatments under study. Treatment T_{10} (NAA @200 ppm) received the significantly maximum branches per plant at 45 DAS (5.47), 75 days after sowing (8.40) and at final harvest (8.53) which was statistically at par with treatment T_9 (NAA @100 ppm), T_{12} (Thiourea @200 ppm), T_{11} (Thiourea @100 ppm) and T_9 (NAA@100 ppm) at 75 DAS and at final harvest while, minimum number of branches per plant at 45 and 75 DAS (4.33 & 6.13, respectively) and at final harvest stage(6.67) were reported with T_1 (Absolute control).

The rise in branch number with NAA treatment may be due to the auxin stimulating metabolic activity and promoting the growth of axillary buds, which leads to more branches (Patel *et al*., 2011) [13]. Similar results also found by Anitha *et al*. (2006) [1] in horse gram and Sahu and Verma (2020) [16] in yard long bean.

Further, The data related to influence of different treatments on days to flower initiation, days to firstpicking and days taken to last picking was showed non significant difference for effect of foliar application of NAA, ascorbic acid and plant nutrients on days taken for initiation of flower.

Yield parameters

Data presented in Table 2 revealed that the maximum number of pods per cluster (3.47) was found with treatment T_{10} (NAA @200 ppm) which was found statistically at par with treatment T_9 (NAA @ 100 ppm), T_{12} (Thiourea @200 ppm) and T_{11} (Thiourea @ 100 ppm), while significantly maximum clusters per plant (29.27) was recorded in treatment T_{10} (NAA @200 ppm) which was statistically at par with T_9 (NAA@100ppm) and T_8 (Potassium nitrate@0.6%) whereas, minimum clusters per plant (18.07) was observed with treatment T_1 (Absolute control). The foliar application of NAA increases maximum number of pods per plant.

This might be due to exogenous application of PGR stimulating the enzymatic activities for naturally occurring hormones that increase the size of photosynthetic apparatus leaf growth and in terms of foliage weight as well as increases assimilation rate contributed for increased number of pods per plant and clusters per plant (Patel *et al*., 2011) [13]. The results are in accordance with the findings of Thaware *et al.* (2006) [19] and Sati *et al.* (2014) [18] in cowpea.

Significantly maximum pickings (7.00) was observed in the treatment T_6 (Ascorbic acid @ 200 ppm), T_8 (Potassium nitrate @ 0.6%), T_9 (NAA @100 ppm) and T_{10} (NAA @200 ppm) theses treatments were statistically at par with the treatment T_4 (Ortho salicylic acid @ 0.3%), T_5 (Ascorbic acid @ 100 ppm), T_{11} (Thiourea @ 100 ppm), T_3 (Ortho salicylic acid @ 0.2%)

and T_{12} (Thiourea @ 200 ppm). While, minimum number of pickings (6.13) recorded with treatment T_1 (Absolute control).

The foliar application of NAA, ascorbic acid and potassium nitrate increases the number of pickings. This is in direct correlation with maximum pods per cluster and clusters per plant. The results are in line with the findings of Sarvaiya *et al.* (2021) [17] in cowpea.

Influence of various treatments on the number of pods per cluster and number of cluster per plant are summarized in Table 2 and data revealed that significantly higher yield per plant (166.75 g) was reported in treatment T_{10} (NAA @200 ppm) which was statistically at par with treatment T_{11} (Thiourea @100 ppm) and T_9 (NAA @100 ppm). While, minimum yield per plant (114.28g) was reported in treatment T_1 (Absolute control).

Increase in yield per plant with foliar application of NAA may be because of a reduction in flower drop, fruit abortion, maximum number of pods per cluster and clusters per plant (Sarvaiya *et al.*, 2021) [17]. Similar results were found by Das and Prasad (2003) [3] in mung bean, Resmi and Gopalkrishnan (2004) [15] in yard long bean and Patil *et al.* (2005) [14] in green gram.

Influence of different treatments on yield per plot (kg) and per hectare (q) clearly indicated that maximum yield per plot (4.01 kg) and yield per ha (123.76 q) was reported in treatment T_{10} (NAA @200 ppm) which was found at par with treatment T_9 (NAA @ 100 ppm), T_{11} (Thiourea @ 100ppm) and T_7 (Potassium nitrate @ 0.4%) while, minimum yield per plot (2.72 kg) and yield per ha (83.84 q) was reported with treatment T_1 (Absolute control).

Increase in yield per hectare with foliar application of NAA was because of a maximum number of pods per cluster, clusters per plant, reduction in flower drop and fruit abortion (Sarvaiya *et al.*, 2021) [17]. Similar results were also found by Das and Prasad (2003) [3] in mung bean, Resmi and Gopalkrishnan (2004) [15] in yard long bean, Patil *et al.* (2005) [14] in green gram, Sati *et al.* (2014) [18] and Sahu and Verma (2020) [16] in cowpea.

Quality parameters

Influence of different treatments on number of seeds per pod are summarized in Table 3 and data revealed that significantly highest number of seeds per pod (12.60) was recorded with treatment T_{10} (NAA @200 ppm) which was found statistically at par with T_9 (NAA @100 ppm). While, minimum number of seed per pod (8.87) was observed with treatment T_1 (Absolute control). Similar results also found by Anitha *et al.* (2006) [1] in horse gram.

Significantly maximum chlorophyll a (0.69 mg/g) with treatment T_9 (NAA@100 ppm) and T_{10} (NAA @200 ppm), chlorophyll b (0.58 mg/g) with treatment T_{10} (NAA @200 ppm) and total chlorophyll (1.24 mg/g) was detected in treatment T_6 (Ascorbic acid @100 ppm), T_9 (NAA @100 ppm), T_{10} (NAA @200 ppm), T_{11} (Thiourea @100 ppm) and T_{12} (Thiourea @200 ppm) which was at par with treatment T_6 (Ascorbic acid @200 ppm), T_{12} (Thiourea @200 ppm), T_{11} (Thiourea @100 ppm), T_5 (Ascorbic acid @100 ppm), T_3 (Ortho salicylic acid @0.2%), T_4 (Ortho salicylic acid @0.3%), T_7 (Potassium nitrate @0.4%) and T_8 (Potassium nitrate @0.6%) in chlorophyll a, T_9 (NAA@100 ppm), T_{12} (Thiourea @200 ppm), T_5 (Ascorbic acid @100 ppm), T_6 (Ascorbic acid @200 ppm), T_{11} (Thiourea @100 ppm), T_8 (Potassium nitrate @0.6%), T_3 (Ortho salicylic acid @0.2%), T_4 (Ortho salicylic acid @0.3%) and T_7 (Potassium nitrate @0.4%) in chlorophyll b and T_5 (Ascorbic acid @100 ppm), T_8 (Potassium nitrate @0.6%), T_4 (Ortho salicylic acid @0.3%), T_7 (Potassium nitrate @0.4%) and T_3 (Ortho salicylic acid @0.2%) in total chlorophyll of pod.

The agrochemicals and growth substances such as NAA had positive effect on cell division, cell elongation leading to enhanced leaf expansion, leaf area and there by chlorophyll content also. The increase in chlorophyll content due to growth regulators may be attributed to decreased chlorophyll degradation and increased chlorophyll synthesis (Bhadane *et al.*, 2020) [2].

Influence of different treatments on crude fiber content, number of root nodules per plant at final picking was found non-significant.

Table 1: Influence of foliar application of antioxidants, plant nutrients and NAA on morphological parameters of cowpea [*Vigna unguiculata* (L.) Walp.]

Treatments	Plant height (cm)			Number of branches per plant			Days taken for initiation of flower	Days taken for first picking	Days taken for last picking
	45 DAS	75 DAS	At final harvest	45 DAS	75 DAS	At final harvest			
T_1	40.33	47.94	59.34	4.33	6.13	6.67	59.27	75.33	101.27
T_2	41.27	49.68	60.10	4.67	6.20	6.73	58.07	73.93	102.60
T_3	44.19	55.90	63.83	4.93	6.87	7.93	55.53	70.33	102.33
T_4	45.87	56.80	64.33	5.00	6.93	7.07	56.73	71.73	103.73
T_5	42.56	56.70	64.20	4.97	6.80	7.00	58.00	74.40	106.40
T_6	46.67	52.87	65.77	4.99	6.47	6.93	57.90	74.93	106.93
T_7	45.90	57.43	60.33	4.73	6.93	7.13	57.80	74.40	106.40
T_8	42.60	57.63	66.87	4.93	7.47	7.53	56.53	71.27	103.27
T_9	47.39	57.80	66.89	5.13	7.93	8.00	54.33	69.27	105.27
T_{10}	48.19	58.33	67.10	5.47	8.40	8.53	55.80	70.60	108.33
T_{11}	53.10	65.98	72.93	5.03	7.07	7.20	56.53	71.33	103.33
T_{12}	53.45	66.40	73.47	5.07	7.13	7.67	56.80	71.07	103.07
S.Em.±	1.60	1.88	2.42	0.16	0.30	0.29	1.91	1.92	2.03
C.D. at 5%	4.69	5.51	7.10	0.46	0.88	0.85	NS	NS	NS
C.V.(%)	6.03	5.71	6.41	5.48	7.43	6.80	5.82	4.59	3.37

Table 2: Influence of foliar application of antioxidants, plant nutrients and NAA on yield of cowpea [*Vigna unguiculata* (L.) Walp.]

Treatments	Number of pods per cluster	Number of clusters per plant	Number of pickings	Yield per plant (g)	Yield per plot (kg)	Yield per hectare (q)
T_1	2.33	18.07	6.13	114.28	2.72	83.84
T_2	2.80	20.25	6.47	117.50	2.79	86.11
T_3	3.00	21.53	6.87	128.05	3.13	96.71
T_4	3.07	23.60	6.93	146.05	3.49	107.69
T_5	3.00	23.67	6.93	134.19	3.20	98.86
T_6	3.00	24.60	7.00	134.44	3.21	99.08
T_7	3.13	25.53	6.93	151.11	3.63	112.13
T_8	3.13	26.27	7.00	150.03	3.58	110.60
T_9	3.40	27.47	7.00	159.70	3.85	118.78
T_{10}	3.47	29.27	7.00	166.75	4.01	123.76
T_{11}	3.20	25.87	6.93	153.95	3.72	114.72
T_{12}	3.33	22.80	6.87	137.01	3.31	102.17
S.Em.±	0.11	1.14	0.09	4.93	0.13	4.03
C.D. at 5%	0.32	3.33	0.28	14.46	0.38	11.83
C.V.(%)	6.06	8.18	2.38	6.05	6.68	6.68

Table 3: Influence of foliar application of antioxidants, plant nutrients and NAA on quality of cowpea [*Vigna unguiculata* (L.) Walp.]

Treatments	Number of seeds per pod	Number of root nodules per plant at final harvest	Crude fiber content (%)	Chlorophyll content of pod (mg/g)		
				Chlorophylla	Chlorophyllb	Total chlorophyll
T_1	8.87	13.17	12.04	0.59	0.50	1.09
T_2	8.93	14.30	12.15	0.62	0.50	1.12
T_3	9.67	14.57	12.41	0.66	0.54	1.21
T_4	10.00	14.50	12.41	0.66	0.54	1.22
T_5	10.13	14.63	12.03	0.67	0.56	1.23
T_6	10.80	14.53	12.02	0.68	0.56	1.24
T_7	10.87	14.80	12.59	0.66	0.54	1.22
T_8	11.07	14.93	12.62	0.66	0.55	1.23
T_9	12.33	14.50	12.50	0.69	0.57	1.24
T_{10}	12.60	15.10	12.51	0.69	0.58	1.24
T_{11}	11.93	14.50	12.56	0.68	0.56	1.24
T_{12}	12.00	15.47	12.43	0.68	0.57	1.24
S.Em.±	0.17	0.39	0.23	0.02	0.01	0.03
C.D. at 5%	0.51	NS	NS	0.06	0.04	0.08
C.V.(%)	2.79	4.57	3.23	4.98	4.73	4.09

Conclusion

As per the results obtained in the present investigation, it is concluded that foliar application of NAA at 200 ppm at 30, 45, and 60 days after sowing is effective for achieving higher growth, yield, and quality in cowpea.

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