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Studies on foliar application of plant growth promoters and micronutrients in onion (*Allium Cepa* L.) under hilly areas of Karnataka determining yield and quality

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ABSTRACT

Investigation was carried out during 2021- 22 at the vegetable science farm of COH(College of Horticulture), Mudigere on the significance of plant growth promoters and micronutrients in onion variety Bhima Shakti under the hill zones of Karnataka. Treatments include the growth promoters (GA_3 and NAA) applied at three different concentrations viz., 75 ppm, 100 ppm, 125 ppm and micronutrients ($ZnSO_4$ and Boron) at two different concentrations viz., 0.25% and 0.50%. Growth promoters and micronutrients had a significant impact in onion on its growth and yield. The experiment consisted of eleven treatments with three replications laid out in Randomized complete block design. Total bulb yield (34.50 t ha^{-1}), marketable bulb yield (33.30 t ha^{-1}), A grade bulb yield (53.81 % and 18.56 t ha^{-1}), gross returns (₹ 5,44,820), net returns (₹ 3,69,514) and benefit cost ratio (2.11) were obtained maximum with the application of GA_3@100ppm with minimum unmarketable yield (1.20 t ha^{-1}) and C grade bulb yield (6.80 % and 2.34 t ha^{-1}). B grade bulb yield (39.06 % and 12.24 t ha^{-1}) observed the highest in NAA@100ppm. Quality parameters such as polar diameter (5.69 cm) and equatorial diameter (5.94 cm) observed significantly maximum in the same treatment GA_3@100ppm. Thus, the application of gibberellic acid at optimal concentration of 100ppm was considered best for obtaining maximum yield, good quality bulbs with higher returns and benefit cost ratio.

1. Introduction

Onion coming under the family Alliaceae is an biennial herbaceous plant. They are primarily originated from Central Asia and secondarily originated from East and Mediterranean regions. Onions are grown throughout India for its edible bulb which is the modification of stem. In India, onions occupy 1.62 million hectares in area with 26.64 million tonnes as its total production (Anon., 2021). Maharashtra, Karnataka, Madhya Pradesh, Gujarat, are the leading states in onion production in India. Onions are grown throughout the year in Karnataka and is cultivated around the area of 0.20 million hectare with the production of 3.85 million tonnes (Anon., 2020). The bulbs are rich in vitamins, minerals, nutrients and antioxidants like quercetin. Alliums exhibit a characteristic pungent smell on chopping which is due to sulphur containing volatile compound called allyl propyl disulphide. Onions are used in homeopathy, Unani, Ayurvedic medicines preparation and involved in the treatment of cancer, heart diseases and digestion disorders. Onions are considered as foreign exchange earning crop since it is exported to many foreign countries due to its huge demand. Hence the productivity of onions should be increased to cater the needs of many countries. Nutrients availability is an important factor in deciding the onion production since more amount of nutrients are required for the bulb development. Unavailability of sufficient nutrients for growth is a major hinderance in the production of onion. Plant growth promoters and micronutrients are involved in various physiological and metabolic process. They alter the physiology of the plant and improves the cellular functions, thereby enhancing its growth and yield with obtaining superior quality. The present study interrogates the

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significance of various growth promoter and micronutrients in increasing the onion bulb yield.

2. Material and Methods

The experimental site was conducted at vegetable science farm located at COH(College of Horticulture), Mudigere, KSNUAHS (Shivamogga) during 2021- 22 in Rabi season. The site is located in hilly region of Western Ghats (Zone-9) at an altitude ranging 982 m above mean sea level with latitude of 13˚25'N and longitude of 75˚25'E. The onion variety Bhima Shakti was used in the present study with following all the standard cultivation practices. The experiment consisted of eleven treatments with three replications laid out in Randomized complete block design (RCBD). Analysis of variance (ANOVA) continued with Duncan's Multiple Range Test(DMRT) to test for differences among the treatments at 5 per cent level of significance (Panse & Sukhatme, 1985).

Treatment Details

Treatment notation	Treatment details
T_1	NAA@75ppm
T_2	NAA@100ppm
T_3	NAA@125ppm
T_4	GA_3@75ppm
T_5	GA_3@100ppm
T_6	GA_3@125ppm
T_7	$ZnSO_4$@0.25%
T_8	$ZnSO_4$@0.50%
T_9	Boron@0.25%
T_{10}	Boron@0.50%
T_{11}	Control

Onion bulb yield (t ha^{-1})

Harvesting of onion bulbs was done at 120 days after transplanting. The total bulb yield, marketable bulb yield and unmarketable bulb yield were recorded for each treatment and expressed in tonnes per hectare (t ha^{-1}). Marketable bulb yield was obtained by adding the bulb yield under A grade, B grade and C grade. Subtracting the marketable bulb yield from the total bulb yield gives the unmarketable bulb yield.

Marketable bulb yield = A grade bulb yield + B grade bulb yiel

Unmarketable yield = Total bulb yield - Marketable bulb yield

Onion grades

Onion bulbs are divided into three grades *viz.,* A, B and C grade on the basis of bulb diameter which is measured using digital vernier callipers (Mitutoyo). Bulb diameter with 5.5 cm and more were regarded as A grade bulbs while the bulb diameter with 4.5 cm to 5.5 cm were regarded as B grade bulbs. Bulbs with the diameter of 3.5 cm to 4.5 cm were regarded as the C grade bulbs. Bulb yield were computed under A, B and C grades for each treatment and expressed in both per cent (%) and tonnes per hectare (t ha^{-1}).

$$\text{A/B/C grade bulb yield (\%)} = \frac{\text{A/B/C grade bulb yield (t ha}^{-1}\text{)}}{\text{Total bulb yield (t ha}^{-1}\text{)}} \times 100$$

Bulb diameter (cm)

Bulb diameter comprises of both polar diameter and equatorial diameter. Polar diameter is obtained by measuring the length between two polar ends of the bulb and equatorial diameter of bulb at the middle of the polar length was measured by digital vernier calipers and expressed in centimeters.

Bulb shape index

Bulb shape index was calculated by dividing the polar diameter with the equatorial diameter. Bulbs with index value less than one have flat shape while more than one have torpedo shape. Bulbs with index value equal to one have globular shape.

$$\text{Bulb shape index} = \frac{\text{Polar diameter}}{\text{Equatorial diameter}}$$

Onion cost economics

Cost economics of onion for each treatment was computed for one hectare. Gross returns and net returns were calculated for each treatment by considering the bulb yield under each grade and expressed in rupees per hectare. Benefit cost ratio was calculated by dividing the net returns with the total cost of cultivation.

$$\text{BCR} = \frac{\text{Net returns}}{\text{Total cost of cultivation}}$$

3. Results and Discussion

Onion bulb yield (t ha^{-1})

Onion bulb yield had shown significant variations among the different treatments and the results obtained were enumerated in Table 1. The total bulb yield (34.50 t ha^{-1}) recorded significantly maximum in the application of GA_3@100ppm (T_5) over control which recorded minimum bulb yield of 25.26 t ha^{-1}. This might be due to the presence of more photosynthates which lead to increased bulb size and hence increase the bulb yield. The same was also reported by Dwivedi & Asati (2019) in onion. Significant differences exist on marketable bulb yield and unmarketable bulb yield with the application of different plant growth promoters and micronutrients. Application of gibberellic acid at 100 ppm (T_5) observed to give the highest marketable bulb yield (33.30 t ha^{-1}) compared to control (22.19 t ha^{-1}). However, the control showed the maximum unmarketable yield (3.07 t ha^{-1}) while the treatment GA_3@100ppm showed the minimum unmarketable yield (1.20 t ha^{-1}).

Application of gibberellins improves the cell membrane permeability and which in turn increases the nutrient uptake capacity. Initially during vegetative stage maximum quantity of food materials such as carbohydrates are stored in the source (leaves). Food materials are translocated efficiently to the sink (bulb) from the source after the completion of vegetative stage. Due to more accumulation of food materials in the sink, bulbs could effectively uptake and utilize the nutrients for bulb development. This might lead to the increased bulb size and bulb quality. Gibberellic acid at optimum concentration of 100ppm showed the highest yield than the lower and higher concentrations of gibberellins, as they might cause the toxicity problems. Hence maximum marketable yield and minimum unmarketable yield were recorded in treatment GA_3@100ppm. The findings were in accordance with Singh *et al.* (2019) in onion. Control received no such treatments and observed the lowest marketable yield when compared to other treatments. Highest unmarketable bulb yield in control could be due to the absence of plant growth promoters and micronutrients application, which obtained poor quality of bulbs compared to other treatments.

Onion grades

The three different grades of onion *viz.,* A, B and C exhibited significant differences with the application of various plant growth promoters and micronutrients (Fig. 1). The results obtained were presented in Table 2. The treatment GA_3@100ppm (T_5) observed the highest A grade bulb yield (53.81 % and 18.56 t ha^{-1}) and the lowest C grade bulb yield (6.80 % and 2.34 t ha^{-1}). B grade bulb yield (39.06 % and 12.24 t ha^{-1}) recorded maximum in the application of growth promoter NAA at 100ppm. Application of growth regulators could greatly reduce the weight loss of bulbs and favors good quality bulbs. This in turn maximised the marketable bulb yield by increasing the yield of both A grade and B grade bulbs. Similar findings were reported by Kashyap (2012) in onion.

Control (T_{11}) recorded the highest C grade bulb yield (17.76 % and 4.49 t ha^{-1}), lowest A grade bulb yield (37.92% and 9.58 t ha^{-1}) and B grade bulb yield (32.14 % and 8.12 t ha^{-1}) as control received lesser amount of nutrients compared to the other treatments and obtained inferior bulbs. This caused reduction in the bulb size and accordingly both A grade and B grade bulb yield got reduced in the control. Hence the C grade bulb yield obtained more in the control. Similar findings were reported by Singh *et al.* (2019) in onion.

Bulb diameter (cm)

Onion bulb yield is largely determined by bulb diameter which includes polar diameter and equatorial diameter. Bulb diameter parameters such as polar diameter and equatorial diameter varied significantly. Polar diameter in onion (5.69 cm) was observed significantly maximum in GA_3@100ppm (T_5) while control observed minimum polar diameter (4.54 cm). In control, equatorial diameter observed minimum (4.80 cm) whereas the equatorial diameter was larger (5.94 cm) in application of gibberellic acid at 100 ppm (T_5) than the control. Here the equatorial diameter was larger than the polar diameter of the bulb. (Table 1)

Application of gibberellins induced rapid cell division and cell elongation and this might induce the highest bulb diameter. Gibberellic acid at an optimum concentration of 100ppm increased the diameter than the lower and higher concentrations. The bulb yield correlated with the bulb diameter. As the application of gibberellins at 100ppm augmented the weight of the bulb, both polar diameter and equatorial diameter in return might get increased. More amount of photosynthates (food reserves) were accumulated in GA_3@100ppm due to source sink relationship and this may also increase the polar diameter and equatorial diameter. The findings of Patel *et al.* (2010), Kashyap (2012) and Dwivedi *et al.* (2019) in onion were similar with the present experimental results.

Bulb shape index

Bulb shape index is one of the commercial traits which decides the bulb shape. In the present study, bulb shape index showed no significant differences with the application of various plant growth promoters and micronutrients in onion.

Onion Cost Economics

Benefit cost ratio was calculated in onion for a hectare and presented in Table 3. Cost economics is an important parameter that decides the economic feasibility on the cultivation practice of a crop. Here, the application of gibberellins at 100ppm (T_5) obtained maximum gross returns (₹ 5,44,820) and net returns (₹ 3,69,514) due to the highest bulb yield and good quality bulbs compared over the control (T_{11}) which obtained minimum gross returns (₹ 3,31,700) and net returns (₹ 1,77,394). A grade bulb yield was the highest in treatment GA_3@100ppm over other treatments and these A grade bulbs fetches good price in the market. Control receives no such treatment effects and so recorded the lowest bulb yield and poor quality bulbs compared over the other treatments. C grade bulbs which fetch lower price in the market obtained maximum yield in the control and minimum in the treatment GA_3@100ppm. This facilitates the lower returns in the control and higher returns in the treatments. Control obtained the lowest benefit cost ratio (1.15) due to the minimum returns obtained in the study. Treatment GA_3@100ppm (T_5) obtained the highest benefit cost ratio (2.11) due to maximum gross and net returns. Cost incurred with the plant growth promoters and micronutrients are compensated by the higher returns, which is greater than the inputs cost. This was in accordance with the The experimental findings of Dwivedi and Asati (2019) in onion and Kadi *et al.* (2018) in cucumber were similar with the present results.

4. Conclusion

Application of plant growth promoters and micronutrients significantly influenced onion bulb yield and its various grades, bulb diameter. Bulb shape index made no impact in this study. Marketable bulb yield, A grade bulb yield, polar diameter, equatorial diameter, benefit cost ratio, gross returns and net returns were obtained maximum in GA_3@100ppm while the B grade bulb was obtained maximum in NAA@100ppm. It was concluded that the application of growth promoter Gibberellic acid at the optimal concentration of 100ppm in onion variety Bhima Shakti was ideal to get good yield, quality and returns with high benefit cost ratio under the hill zones of Karnataka.

5. Acknowledgement

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Table 1. Effect of growth promoters and micronutrients on yield and quality of onion

Treatments	Total Bulb yield (t/ha)	Marketable bulb yield (t/ha)	Un marketable bulb yield (t/ha)	Polar diameter of bulb (cm)	Equatorial diameter of bulb (cm)	Bulb shape index
T_1 - NAA@75ppm	27.58^{cd}	26.36^{c}	1.22^{c}	5.19^{cd}	5.44^{cd}	0.96^{a}
T_2 - NAA@100ppm	31.32^{b}	30.08^{b}	1.24^{c}	5.61^{ab}	5.89^{a}	0.95^{a}
T_3 - NAA@125ppm	26.72^{d}	24.18^{e}	2.54^{b}	4.63^{e}	5.11^{ef}	0.91^{a}
T_4 - GA_3@75ppm	28.00^{cd}	26.79^{c}	1.21^{c}	5.45^{abc}	5.68^{abc}	0.96^{a}
T_5 - GA_3@100ppm	34.50^{a}	33.30^{a}	1.20^{c}	5.69^{a}	5.94^{a}	0.96^{a}
T_6 - GA_3@125ppm	27.75^{cd}	26.47^{c}	1.28^{c}	5.37^{bc}	5.50^{bcd}	0.98^{a}
T_7 - $ZnSO_4$@0.25%	27.33^{cd}	25.77^{cd}	1.56^{c}	4.99^{d}	5.26^{de}	0.95^{a}
T_8 - $ZnSO_4$@0.50%	28.33^{c}	26.90^{c}	1.43^{c}	5.58^{ab}	5.80^{a}	0.96^{a}
T_9 -Boron @0.25%	26.81^{cd}	24.67^{de}	2.14^{b}	4.72^{e}	4.92^{fg}	0.96^{a}
T_{10} -Boron @0.50%	28.30^{c}	26.86^{c}	1.44^{c}	5.50^{ab}	5.73^{ab}	0.96^{a}
T_{11} -Control	25.26^{e}	22.19^{f}	3.07^{a}	4.54^{e}	4.80^{g}	0.95^{a}
Mean	**28.35**	**26.69**	**1.67**	**5.21**	**5.46**	**NS**

S.Em±	**0.45**	**0.42**	**0.14**	**0.08**	**0.08**	**NS**
CD (P=0.05)	**1.34**	**1.23**	**0.41**	**0.24**	**0.25**	**NS**

[*]Mean with same letter within a column are not significantly different in DMRT test (alpha=0.05)

Table 2. Effect of growth promoters and micronutrients on grading in onion

Treatments	**A grade**		**B grade**		**C grade**	
	%	**t ha^{-1}**	**%**	**t ha^{-1}**	**%**	**t ha^{-1}**
T_1- NAA @ 75 ppm	42.30^{c}	11.67	36.86^{de}	10.15	16.43^{ab}	4.43
T_2- NAA @ 100 ppm	46.86^{b}	14.68	39.06^{a}	12.24	10.12^{d}	3.17
T_3- NAA @ 125 ppm	42.15^{c}	11.26	37.43^{abcde}	10.00	10.91^{d}	2.92
T_4- GA_3 @ 75 ppm	42.35^{c}	11.86	38.05^{abcd}	10.65	15.27^{bc}	4.28
T_5 - GA_3 @ 100 ppm	53.81^{a}	18.56	35.93^{e}	12.39	6.80^{e}	2.34
T_6 - GA_3 @ 125 ppm	42.32^{c}	11.74	37.25^{bcde}	10.34	15.81^{ab}	4.39
T_7 - $ZnSO_4$ @ 0.25%	42.29^{c}	11.56	37.10^{cde}	10.14	14.90^{bc}	4.07
T_8 - $ZnSO_4$ @ 0.50%	42.76^{c}	12.11	38.77^{abc}	10.98	13.43^{c}	3.80
T_9 – Boron @ 0.25%	42.27^{c}	11.33	36.14^{e}	9.68	13.60^{c}	3.66
T_{10} – Boron @ 0.50%	42.63^{c}	12.07	38.98^{ab}	11.03	13.31^{c}	3.76
T_{11}- Control	37.92^{d}	9.58	32.14^{f}	8.12	17.76^{a}	4.49
Mean	**43.42**	**12.40**	**37.06**	**10.52**	**13.48**	**3.77**
S.Em ±	**0.29**	**0.21**	**0.55**	**0.17**	**0.68**	**0.23**
CD (P=0.05)	**0.84**	**0.61**	**1.63**	**0.49**	**2.02**	**0.67**

Table 3. Cost economics of growth promoters and micronutrients in onion

Treatment	Total cost of cultivation	A grade		B grade		C grade		Gross Returns	Net returns	B:C ratio
		t ha^{-1}	returns	t ha^{-1}	returns	t ha^{-1}	returns			
T_1- NAA @ 75 ppm	1,66,681	11.67	2,21,730	10.15	1,42,100	4.54	36,320	4,00,150	2,33,469	1.40
T_2- NAA @ 100 ppm	1,70,806	14.68	2,78,920	12.24	1,71,360	3.17	25,360	4,75,640	3,04,834	1.78
T_3- NAA @ 125 ppm	1,74,931	11.26	2,13,940	10.00	1,40,000	2.92	23,360	3,77,300	2,02,369	1.16
T_4- GA_3 @ 75 ppm	1,70,056	11.86	2,25,340	10.65	1,49,100	4.28	34,240	4,08,680	2,38,624	1.40
T_5 - GA_3 @ 100 ppm	1,75,306	18.56	3,52,640	12.39	1,73,460	2.34	18,720	5,44,820	3,69,514	2.11
T_6 - GA_3 @ 125 ppm	1,80,556	11.74	2,23,060	10.34	1,44,760	4.39	35,120	4,02,940	2,22,384	1.23
T_7 - $ZnSO_4$ @ 0.25%	1,55,956	11.56	2,19,640	10.14	1,41,960	4.07	32,560	3,94,160	2,38,204	1.53
T_8 - $ZnSO_4$ @ 0.50%	1,57,606	12.11	2,30,090	10.98	1,53,720	3.80	30,400	4,14,210	2,56,604	1.63
T_9 – Boron @ 0.25%	1,55,993	11.33	2,15,270	9.68	1,35,520	3.66	29,280	3,80,070	2,24,077	1.44
T_{10} – Boron @ 0.50%	1,57,681	12.07	2,29,330	11.03	1,54,420	3.76	30,080	4,13,830	2,56,149	1.62
T_{11}- Control	1,54,306	9.58	1,82,020	8.12	1,13,680	4.49	36,000	3,31,700	1,77,394	1.15

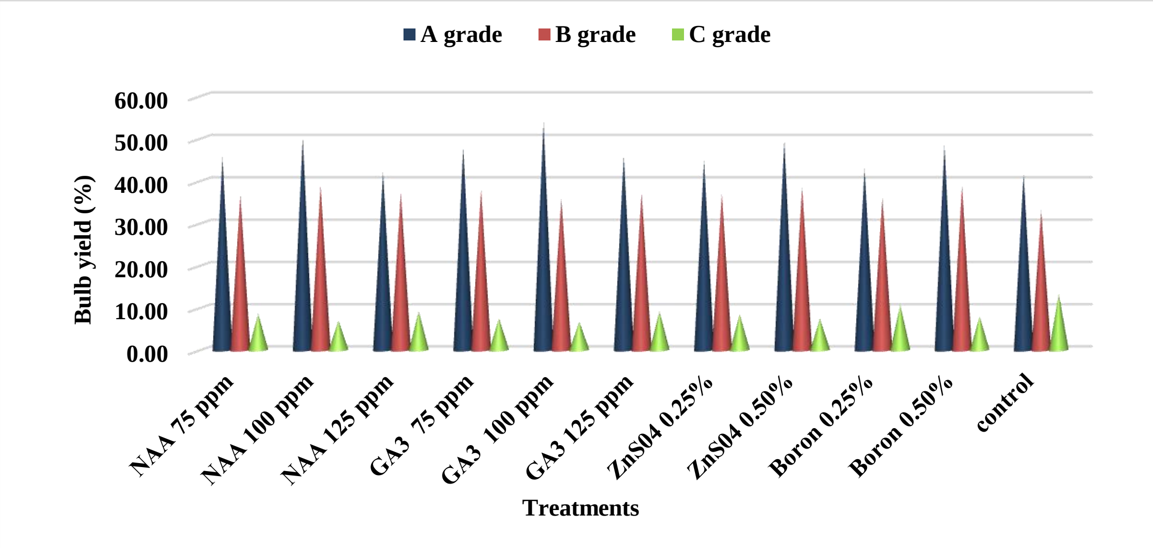

Figure 1. Effect of plant growth promoters and micronutrients on onion bulb grades (%)