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Response of *Kharif* Onion (*Allium cepa* L.) for Growth and Yield to Different Doses of Sulphur, GA_3 and NAA

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The present investigation entitled "Response of *Kharif* onion (*Allium cepa* L.) for growth and yield to different doses of Sulphur, GA_3 and NAA" was carried out during *kharif* 2016 –17 (first year) and 2017 – 18 (second year) at the experimental field RVSKVV, Krishi Vigyan Kendra, Rajgarh (M.P.) with 27 treatment combinations of three levels of sulphur i.e. 0, 20 and 40 $kgha^{-1}$, three levels of Gibberellic acid viz., 0, 50 and 100 ppm and three levels of NAA i.e. 0, 50 and 100 ppm. Results obtained for 2016-17 and 2017-18 and in pooled basis revealed that the application of 40 kg S ha^{-1} was recorded significantly maximum plant height, number of leaves per plant, bulb/ green top ratio and neck diameter and yield attributes such as fresh weight of bulb, polar and equatorial diameter of bulb and bulb yield per hectare in both the year and in pooled. Foliar application of GA_3 @ 50ppm (G_1) and NAA @ 100 PPM (N_2) at seedling stage and after 30 days after transplanting also exhibited significantly maximum growth and yield. It was concluded that various growth and yield parameters were improved with the application of S 40 Kg/ha+ GA_3 50 ppm + NAA100ppm for higher yield and quality of *Kharif* Onion.

Introduction

Onion (*Allium cepa* L.) is one of the most important bulbous vegetable crops grown all over the world. The demand for onion is worldwide and it is found in most market of the world thought out the year. Onion is the oriented crop earning valuable foreign exchange for the country. It is an indispensable item in every kitchen and used to enhance flavour of different recipes. Onion has many medicinal values and used for preparation of various Homeopathic, Unani and Ayurvedic medicines. Researchers found that the more pungent onions exhibit strong anti-platelet activity. The production of *kharif* onion has several advantages i.e. increases total production per annum and fulfils the demand of fresh onion in the market. *Kharif* onion provides high price as compared to *Rabi* season crop. Application of sulphur not only increases the bulb yield but also improve its quality especially pungency and flavors. Sulphur deficient plants had poor utilization of nitrogen, phosphorus and potash. The translocation of food materials or for altering source to sink relationship is changed by application of plant growth regulators. Gibberellic acid stimulates cell division and elongation, germination of seeds, prevention of genetic dwarfism, increase flower and fruit size, dormancy and extending shelf life.

Naphthalene Acetic Acid (NAA) plays key role in cell elongation, cell division, vascular tissue differentiation, root initiation, apical dominance, leaf senescence, leaf and fruit abscission, fruit setting and flowering

Materials and Methods

The present investigation entitled "Response of Response of *Kharif* onion (*Allium cepa* L.) For growth and yield to different levelses of Sulphur, GA_3 and NAA" was carried out during *kharif* 2016 – 17 (first year) and 2017 – 18 (second year) at the experimental field, Krishi Vigyan Kendra, Rajgarh (M.P.). The experimental material was comprised of 27 treatments combinations of three levels of sulphur i.e. 0, 20 and 40 kg ha^{-1}, three levels of Gibberellic acid viz., 0, 50 and 100PPM and three levels of NAA i.e. 0, 50 and 100 PPM. The foliar spray of plant growth regulators i.e. GA_3 and NAA @ 50 and 100 ppm was done at seedling stage and after 30 DAT. Experiments were laid out in Factorial Randomized Complete Block Design with three replications. Observations were recorded on the basis of five random competitive plants selected from each treatment separately for growth and yield parameters and were evaluated as per standard procedure. The pooled data analysis was also performed

Results and Discussion

Effect of sulphur on growth parameters

Significantly maximum 60.01, 62.51 and 61.26 cm plant height was recorded under the treatment S_2 (40 kg S ha^{-1}) significantly followed by 58.07, 60.07 and 59.07 on plant height under the treatment S_1 (20 kg S ha^{-1}) while, it was recorded lowest 52.73, 54.73 and 53.73 cm in treatment S_0 (0 kg S ha^{-1}) at first year, second year and in pooled, respectively (Table 1). Similarly significantly maximum 12.64, 13.34 and 12.99 leaves per plant was recorded under the treatment S_2 (40kg S ha^{-1}) significantly followed by 12.11, 12.61 and 12.36 leaves per plant under the treatment S_1 (20 kg S ha^{-1}) while, it was recorded lowest 10.43, 10.93 and 10.68 in treatment S_0 (0 kg S ha^{-1}) at first year, second year and in pooled, respectively. The significantly maximum 1.46, 2.00 and 1.73 bulb/ green top ratio was registered under the treatment S_2 (40kg S ha^{-1}) it was significantly followed by 1.36, 1.68 and 1.53 bulb/green top ratio under S_1 (20 kg S ha^{-1}), while, it was noted lowest 1.20, 1.50 and 1.35 in treatment S_0 (0 kg S ha^{-1}) at first year, second year and in pooled, respectively. Significantly maximum 1.36, 1.85 and 1.60 cm neck diameter was recorded under the treatment S_2 (40kg S ha^{-1}), while, it was noted lowest 0.85, 1.15 and 1.00 cm in treatment S_0 (0 kg S ha^{-1}) at first year, second year and in pooled, respectively. Application of S 20 kg/ha^{-1} (S1) was found non- significant to treatment S_2 (40kg S ha^{-1}) (Table 1). The present results are therefore in conformity with the results of Suman *et al.,* (2002), Rashid (2010), Jain *et al.,* (2014) and El Sayed *et al.,* (2015). Plant height, number of leaves per plant, bulb/ green top ratio and neck diameter significantly increased with increasing sulphur levels up to 40 kg S ha^{-1}. These results may be due to the beneficial effect of sulphur application as an one of the required elements for plant growth, it is important in protein and chlorophyll formation.

Effect of GA_3 on growth parameters

The treatment G_1 (50ppm) was found significantly superior as compared to G_2 (100 ppm) treatments. Treatment G_1 (50ppm) was recorded significantly maximum plant height 57.63, 59.87 and 58.75 cm (Table 1), while, it was recorded lowest 56.14, 58.23 and 57.19 cm in treatment G_0 (0 ppm i.e. control) at first year, second year and in pooled, respectively. This result was in harmony with those reported by Anwar (2001), Singh *et al.*, (2014), Govind *et al.*, (2015), Trivedi and Dhumal (2017), and Yadagiri *et al.*, (2018). The treatment G_1 (50ppm) was recorded significantly maximum 11.96, 12.56 and 12.26 leaves per plant which was at par with G_2 (100ppm) (11.77, 12.33 and 12.05 leaves per plant), while, it was recorded lowest 11.46, 11.99 and 11.73 in treatment G_0 (0 ppm i.e. control) at first year, second year and in pooled, respectively. Treatment G_1 (50ppm) exhibited significantly maximum 1.38, 1.78 and 1.58 bulb/ green top ratio at par with G_2 (100ppm) (1.35, 1.76 and 1.56), while, it was recorded lowest 1.31, 1.64 and 1.48 in treatment G_0 (0 ppm i.e. control) at first year, second year and in pooled, respectively.

The treatment G_1 (50ppm) exhibited significantly maximum 1.22, 1.62 and 1.42 cm neck diameter which was at par with G_2 (100 ppm), while, it was recorded lowest 1.11, 1.43 and 1.27 cm in treatment G_0 (0 ppm i.e. control) at first year, second year and in pooled, respectively. The results obtained are in conformity with the results of Anwar (2001), Singh *et al.*, (2014), Govind *et al.*, (2015) and Yadagiri *et al.*, (2018). The improving plant growth under spraying of gibberellic acid may be due to the role of gibberellic acid on enhancing cell division activity, increasing of proline accumulation of plant and increasing of endogenous phytohormones i.e. increasing promotion hormones (IAA, GA_3 and cytokinins) and reducing ABA content, which found that plant growth regulators make a shift in hormonal balance characterized by increase in endogenous phytohormon in plant.

Effect of NAA on growth parameters

Significantly maximum 58.34, 60.62 and 59.48 cm plant height was recorded under the treatment N_2 (NAA 100 PPM) at par with N_1 (NAA 50 PPM) (57.90, 57.90 and 60.12 cm), while, it was recorded lowest 54.56, 56.56 and 55.56 cm in treatment N_0 (NAA 0 PPM) at first year, second year and in pooled, respectively. Similarly significantly maximum 12.10, 12.71 and 12.41 leaves per plant was recorded under the treatment N_2 (NAA 100 PPM) at par with N_1 (NAA 50 PPM) (12.0, 12.58 and 12.29 leaves per plant), while, it was recorded lowest 11.09, 11.59 and 11.34 in treatment N_0 (NAA 0 PPM) at first year, second year and in pooled, respectively. Among NAA, significantly maximum 1.40, 1.82 and 1.61 bulb/ green top ratio was noticed under the treatment N_2 (NAA 100 PPM) which was at par with N_1 (NAA 50 PPM) (1.38, 1.81 and 1.60), while, it was observed lowest 1.26, 1.56 and 1.41 in treatment N_0 (NAA 0 PPM) at first year, second year and in pooled, respectively. Significantly maximum 1.23, 1.65 and 1.44 cm neck diameter was noticed under the treatment N_2 (NAA 100 PPM) followed by N_1 (NAA 50 PPM) (1.20, 1.58 and 1.39 cm) at par in first year only, while, it was observed lowest 1.05, 1.35 and 1.20 cm in treatment N_0 (NAA 0 PPM) at first, second year and pooled, respectively.

The present results are therefore in conformity with the results of Bose *et al.*, (2009), Meena *et al.*, (2017) and Pratap *et al.*, (2017). The increase in plant height, leaves per plant, bulb/ green top ratio and neck diameter by foliar spray of NAA 100PPM might be due to rapid increase in cell division and cell elongation in the meristemic region. In general, leaf is considered as an important functional unit of plant which contributes to yield. Probable reason may be due to the role of NAA on enhancing cell division activity, increasing proline accumulation of plant and increasing endogenous phytohormones.

Interaction effect of sulphur, GA_3 and NAA on growth parameters

The maximum 63.60, 66.77 and 65.18 cm plant height were recorded in treatment combination $S_2G_1N_2$ (S 40 Kg/ha+ GA_3 50ppm+ NAA100ppm) followed by $S_2G_1N_1$ (S 40 Kg/ha+ GA_3 50ppm+ NAA50ppm) (61.93, 64.93 and 63.43 cm), while, it was recorded lowest 50.27, 52.27 and 51.27 cm in treatment $S_0G_0N_0$ (S 0 Kg/ha+ GA_3 0ppm+ NAA 0ppm) at first year, second year and in pooled, respectively (Table 2). The maximum 13.43, 14.43 and 13.93 leaves per plant were recorded in treatment combination $S_2G_1N_2$ (S 40 Kg/ha+ GA_3 50ppm+ NAA100ppm) followed by $S_2G_1N_1$ (S 40 Kg/ha+ GA_3 50ppm+ NAA50ppm) (13.33, 14.25 and 13.79), while, it was recorded lowest 9.70, 10.20 and 9.95 in treatment $S_0G_0N_0$ (S 0 Kg/ha+ GA_3 0ppm+ NAA 0ppm) at first year, second year and in pooled, respectively. Similarly significantly maximum 1.57, 2.37 and 1.97 bulb/ green top ratio were recorded in treatment combination $S_2G_1N_2$ (S 40 Kg/ha+ GA_3 50ppm+ NAA100ppm) followed by $S_2G_1N_1$ (S 40 Kg/ha+ GA_3 50ppm+ NAA50ppm) (1.55, 2.26 and 1.91), while, it was recorded lowest 1.13, 1.43 and 1.28 in treatment $S_0G_0N_0$ (S 0 Kg/ha+ GA_3 0ppm+ NAA 0ppm) at first, second year and pooled, respectively. Significantly maximum 1.51, 2.31 and 1.91 cm neck diameter were recorded in treatment combination $S_2G_1N_2$ (S 40 Kg/ha+ GA_3 50ppm + NAA100ppm) followed by $S_2G_1N_1$ (S 40 Kg/ha+ GA_3 50ppm+ NAA50ppm) (1.46, 2.18 and 1.82 cm), while, it was recorded lowest 0.69, 0.99 and 0.84 cm in treatment $S_0G_0N_0$ (S 0 Kg/ha+ GA_3 0ppm+ NAA 0ppm) at first, second year and pooled, respectively. Similar finding were also rep[orted by Sitapara *et al.*, (2011) and Meena *et al.*, (2017) Plant height is a genetically controlled character but several studies have indicated that the plant height can be either increased or decreased by the application of synthetic plant growth regulators and sulphur. Probably may be due to the beneficial cumulative effect of sulphur, GA_3 and NAA. Application of sulphur as a one of the required elements for plant growth, it is important in protein and chlorophyll formation. The increase in plant height, number of leaves per plant, bulb/ green top ratio and neck diameter by foliar spray of GA_3 and NAA might be due to rapid increase in cell division and cell elongation in the meristemic region. The thickness of the stem (neck) is the important parameter for storage of bulb. Hence, more the thickness of the neck, more will be the rotting due to more fungous infection.

Effect of sulphur on yield and yield parameters

Significantly maximum 90.93, 96.46 and 93.69 g fresh weight of bulb was recorded under the treatment S_2 (40kg S ha^{-1}), which was significantly superior to S_1 (20kg S ha^{-1})while, it was noted lowest 74.32, 79.36 and 76.84 g in treatment S_0 (0 kg S ha^{-1}) at first year, second year and in pooled, respectively (Table 3). The Polar diameter of bulb was recorded significantly maximum 5.89, 6.39 and 6.14 cm under the treatment S_2 (40kg S ha^{-1}) which was significantly superior to S_1 (20kg S ha^{-1}) while, it was noted lowest 5.23, 5.53 and 5.38 cm in treatment S_0 (0 kg S ha^{-1}) at first, second year and pooled, respectively. Equatorial diameter of bulb was recorded significantly maximum 4.82, 5.26 and 5.04 cm under the treatment S_2 (40kg S ha^{-1}) whish was significantly superior to treatment S1 (20 kg S ha^{-1}) and it was noted lowest 4.35, 4.65 and 4.50 cm in treatment S_0 (0 kg S ha^{-1}) at first year, second year and in pooled, respectively. The treatment S_2 (40kg S ha^{-1}) was recorded significantly maximum 244.01, 240.31 and 242.16 q/ha bulb yield and it was noted lowest 198.17, 189.17 and 193.67 q/ha in treatment S_0 (0 kg S ha^{-1}) at first year, second year and in pooled, respectively. Similar results were also reported in onion crop by Suman *et al.*, (2002), Rashid (2010), Jain *et al.*, (2014) and El Sayed *et al.*, (2015). The increase in fresh weight of bulb, polar and equatorial diameter of bulb and bulb yield might be attributed to the increased synthesis of sulphur containing amino acids in plants which intern resulted in the formation of healthy Xylem, collenchyma and schlernchyma tissues. It also increased the uptake of N, P, K and S which might have influenced the synthesis and translocation of stored materials to the sink.

Effect of GA_3 on yield and yield parameters

Treatment G_1 (GA_3 @ 50ppm) exhibited significantly maximum 85.69, 90.93 and 88.31 g fresh weight of bulb, which was significantly inferior too treatment G_2 (GA_3 @ 100ppm) while, it was recorded lowest 81.25, 86.46 and 83.85 g in treatment G_0 (0 ppm i.e. control) at first, second year and pooled, respectively. The treatment G_1 (GA_3 @ 50ppm) exhibited significantly maximum 5.69, 6.09 and 5.89 cm polar diameter of bulb, followed by treatment of G_2 (GA_3 @ 100ppm) while, it was recorded lowest 5.52, 5.85 and 5.69 cm in treatment G_0 (0 ppm i.e. control) at first year, second year and in pooled, respectively. Similar results have also been reported by Rashid (2010), Singh *et al.*, (2014) and Yadagiri *et al.*, (2018). Foliar application of GA_3 @ 50ppm (G_1) was exhibited significantly maximum 4.69, 5.11 and 4.90 cm equatorial diameter of bulb followed by treatment G_2 (GA_3 @ 100ppm) while, it was recorded lowest 4.56, 4.89 and 4.73 cm in treatment G_0 (0 ppm i.e. control) at first, second year and pooled, respectively. Foliar application of GA_3 @ 50ppm (G_1) exhibited significantly maximum 231.01, 224.53 and 227.77 q/ha bulb yield which was significantly while which was significantly followed by treatment G2 (GA_3 @ 100ppm) it was recorded lowest 216.73, 208.62 and 212.67 q/ha in treatment G_0 (0 ppm i.e. control) at first year, second year and in pooled, respectively. Similar results were also reported by Rashid (2010), Singh *et al.*, (2014), Govind *et al.*, (2015), Yadagiri *et al.*, (2018) and Thakur *et al.*, (2018). Fresh weight of bulb, polar and equatorial diameter of bulb showed upward trend with the increase in GA_3 concentrations which could be due to the rapid cell division and elongation leading to bigger bulb formation. It could be concluded that the heaviest bulbs yield which resulted may be attributed to the best vigour of plant growth characters which obtained by addition of foliar application of 50PPM GA_3. There is no doubt that, growth regulators play a major role in diverse growth processes including organ elongation and senescence.

Effect of NAA on yield and yield parameters

Significantly maximum 86.73, 92.01 and 89.37 g fresh weight of bulb was noticed under the treatment N_2 (NAA 100 PPM) significantly followed by N_1 (NAA 50 ppm) while, it was observed lowest 78.11, 83.11 and 80.61 g in treatment N_0 (NAA 0 PPM) at first year, second year and in pooled, respectively. Among NAA, significantly maximum 5.73, 6.14 and 5.94 cm polar diameter of bulb was noticed under the treatment N_2 (NAA 100 PPM), followed by N_1 (NAA @ 50 ppm) while, it was observed lowest 5.41, 5.71 and 5.56 cm in treatment N_0 (NAA 0 PPM) at first year, second year and in pooled, respectively. Significantly maximum 4.70, 5.08 and 4.89 cm equatorial diameter of bulb was noticed under the treatment N_2 (NAA 100 PPM) followed by N_1 (NAA @50 ppm) while, it was observed lowest 4.51, 4.84 and 4.68 cm in treatment N_0 (NAA @0 PPM) at first year, second year and in pooled, respectively.

Table.1 Effect of different doses of Sulphur, GA_3 and NAA on growth at harvest in first, second year and pooled

Treat. Symb.	Treatments	Plant height (cm)			No. of leaves/plant			Bulb/green top ratio			Neck diameter (cm)		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
S_0	Sulphur (0 kg/ha)	52.73	54.73	53.73	10.43	10.93	10.68	1.20	1.50	1.35	0.85	1.15	1.00
S_1	Sulphur (20 kg/ha)	58.07	60.07	59.07	12.11	12.61	12.36	1.38	1.68	1.53	1.27	1.57	1.42
S_2	Sulphur (40 kg/ha)	60.01	62.51	61.26	12.64	13.34	12.99	1.46	2.00	1.73	1.36	1.85	1.60
	S.Em±	0.41	0.23	0.21	0.07	0.05	0.04	0.02	0.02	0.02	0.015	0.019	0.015
	C.D. (P 0.05) level	1.18	0.65	0.60	0.19	0.15	0.11	0.05	0.05	0.05	0.042	0.054	0.042
G_0	GA_3 (0 PPM)	56.14	58.23	57.19	11.46	11.99	11.73	1.31	1.64	1.48	1.11	1.43	1.27
G_1	GA_3 (50 PPM)	57.63	59.87	58.75	11.96	12.56	12.26	1.38	1.78	1.58	1.22	1.62	1.42
G_2	GA_3 (100 PPM)	57.03	59.19	58.11	11.77	12.33	12.05	1.35	1.76	1.56	1.15	1.52	1.34
	S.Em±	0.41	0.23	0.21	0.07	0.05	0.04	0.02	0.02	0.02	0.015	0.019	0.015
	C.D. (P 0.05) level	1.18	0.65	0.60	0.19	0.15	0.11	0.05	0.05	0.05	0.042	0.054	0.042
N_0	NAA (0 PPM)	54.56	56.56	55.56	11.09	11.59	11.34	1.26	1.56	1.41	1.05	1.35	1.20
N_1	NAA (50 PPM)	57.90	60.12	59.01	12.00	12.58	12.29	1.38	1.81	1.60	1.20	1.58	1.39
N_2	NAA (100 PPM)	58.34	60.62	59.48	12.10	12.71	12.41	1.40	1.82	1.61	1.23	1.65	1.44
	S.Em±	0.41	0.23	0.21	0.07	0.05	0.04	0.02	0.02	0.02	0.85	1.15	1.00
	C.D. (P 0.05) level	1.18	0.65	0.60	0.19	0.15	0.11	0.05	0.05	0.05	1.27	1.57	1.42

Table.2 Interaction effect of different doses of Sulphur, GA_3 and NAA on growth at harvest in first year, second year and in pooled basis

Treat. Symb.	Treatments	Plant height (cm)			No. of leaves/plant			Bulb/green top ratio			Neck diameter (cm)		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
$S_0G_0N_0$	S (0 Kg/ha) G (0ppm) N(0ppm)	50.27	52.27	51.27	9.70	10.20	9.95	1.13	1.43	1.28	0.69	0.99	0.84
$S_0G_0N_1$	S (0 Kg/ha) G (0ppm) N(50ppm)	53.30	55.30	54.30	10.17	10.67	10.42	1.19	1.49	1.34	0.80	1.10	0.95
$S_0G_0N_2$	S (0 Kg/ha) G (0ppm) N(100ppm)	53.60	55.60	54.60	10.37	10.87	10.62	1.20	1.50	1.35	0.85	1.15	1.00
$S_0G_1N_0$	S (0 Kg/ha) G (50ppm) N(0ppm)	51.33	53.33	52.33	10.07	10.57	10.32	1.17	1.47	1.32	0.76	1.06	0.91
$S_0G_1N_1$	S (0 Kg/ha) G (50ppm) N(50ppm)	53.87	55.87	54.87	11.00	11.50	11.25	1.25	1.55	1.40	0.98	1.28	1.13
$S_0G_1N_2$	S (0 Kg/ha) G(50ppm)N(100ppm)	54.30	56.30	55.30	11.03	11.53	11.28	1.27	1.57	1.42	1.11	1.41	1.26
$S_0G_2N_0$	S (0 Kg/ha) G (100ppm) N(0ppm)	50.47	52.47	51.47	9.93	10.43	10.18	1.15	1.45	1.30	0.72	1.02	0.87
$S_0G_2N_1$	S (0 Kg/ha) G(100ppm)N(50ppm)	53.60	55.60	54.60	10.67	11.17	10.92	1.22	1.52	1.37	0.87	1.17	1.02
$S_0G_2N_2$	S(0 Kg/ha)G(100ppm)N(100ppm)	53.80	55.80	54.80	10.97	11.47	11.22	1.23	1.53	1.38	0.90	1.20	1.05
$S_1G_0N_0$	S(20 Kg/ha)G (0ppm)N(0ppm)	54.80	56.80	55.80	11.57	12.07	11.82	1.28	1.58	1.43	1.16	1.46	1.31
$S_1G_0N_1$	S (20 Kg/ha) G (0ppm) N(50ppm)	58.27	60.27	59.27	12.10	12.60	12.35	1.37	1.67	1.52	1.28	1.58	1.43
$S_1G_0N_2$	S(20 Kg/ha)G (0ppm) N(100ppm)	59.17	61.17	60.17	12.13	12.63	12.38	1.40	1.70	1.55	1.28	1.58	1.43
$S_1G_1N_0$	S(20 Kg/ha) G (50ppm) N(0ppm)	56.73	58.73	57.73	11.67	12.17	11.92	1.32	1.62	1.47	1.20	1.50	1.35
$S_1G_1N_1$	S(20 Kg/ha)G (50ppm) N(50ppm)	59.27	61.27	60.27	12.60	13.10	12.85	1.45	1.75	1.60	1.34	1.64	1.49
$S_1G_1N_2$	S(20 Kg/ha)G(50ppm)N(100ppm)	59.40	61.40	60.40	12.67	13.17	12.92	1.46	1.76	1.61	1.35	1.65	1.50
$S_1G_2N_0$	S (20 Kg/ha)G(100ppm) N(0ppm)	56.63	58.63	57.63	11.63	12.13	11.88	1.30	1.60	1.45	1.17	1.47	1.32
$S_1G_2N_1$	S(20 Kg/ha)G(100ppm)N(50ppm)	59.17	61.17	60.17	12.27	12.77	12.52	1.42	1.72	1.57	1.30	1.60	1.45
$S_1G_2N_2$	S(20Kg/ha)G(100ppm)N(100ppm)	59.17	61.17	60.17	12.40	12.90	12.65	1.44	1.74	1.59	1.33	1.63	1.48
$S_2G_0N_0$	S (40 Kg/ha) G (0ppm) N(0ppm)	55.43	57.43	56.43	11.60	12.10	11.85	1.29	1.59	1.44	1.17	1.47	1.32
$S_2G_0N_1$	S (40 Kg/ha) G (0ppm) N(50ppm)	60.07	62.40	61.23	12.73	13.32	13.03	1.48	1.87	1.68	1.36	1.74	1.55
$S_2G_0N_2$	S(40 Kg/ha) G (0ppm) N(100ppm)	60.37	62.87	61.62	12.80	13.47	13.13	1.50	1.96	1.73	1.37	1.83	1.60
$S_2G_1N_0$	S (40 Kg/ha) G (50ppm) N(0ppm)	58.27	60.27	59.27	11.83	12.33	12.08	1.34	1.64	1.49	1.28	1.58	1.43
$S_2G_1N_1$	S(40 Kg/ha) G (50ppm) N(50ppm)	61.93	64.93	63.43	13.33	14.25	13.79	1.55	2.26	1.91	1.46	2.18	1.82
$S_2G_1N_2$	S(40 Kg/ha)G(50ppm) N(100ppm)	63.60	66.77	65.18	13.43	14.43	13.93	1.57	2.37	1.97	1.51	2.31	1.91
$S_2G_2N_0$	S(40 Kg/ha) G (100ppm) N(0ppm)	57.13	59.13	58.13	11.80	12.30	12.05	1.33	1.63	1.48	1.27	1.57	1.42
$S_2G_2N_1$	S(40 Kg/ha)G(100ppm) N(50ppm)	61.60	64.27	62.93	13.10	13.85	13.48	1.52	2.52	2.02	1.39	1.94	1.67
$S_2G_2N_2$	S(40Kg/ha)G(100ppm)N(100ppm)	61.67	64.50	63.08	13.13	13.97	13.55	1.53	2.16	1.84	1.41	2.04	1.72
	S.Em±	1.25	0.69	0.64	0.20	0.16	0.12	0.06	0.06	0.05	0.04	0.06	0.04
	C.D. (P 0.05) level	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	0.16	N.S.	N.S.	N.S.	N.S.

Table.3 Effect of different doses of Sulphur, GA_3 and NAA on yield traits and yield

Treat. Symb.	Treatments	Fresh weight of bulb (g)			Polar diameter of bulb (cm)			Equatorial diameter of bulb (cm)			Bulb yield ha^{-1} (q)		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
S_0	Sulphur (0 kg/ha)	74.32	79.36	76.84	5.23	5.53	5.38	4.35	4.65	4.50	198.17	189.17	193.67
S_1	Sulphur (20 kg/ha)	85.33	90.37	87.85	5.70	6.00	5.85	4.73	5.03	4.88	230.56	220.96	225.76
S_2	Sulphur (40 kg/ha)	90.93	96.46	93.69	5.89	6.39	6.14	4.82	5.26	5.04	244.01	240.31	242.16
	S.Em±	0.09	0.10	0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.46	0.65	0.48
	C.D. (P 0.05) level	0.26	0.30	0.18	0.02	0.02	0.03	0.02	0.03	0.03	1.32	1.85	1.33
G_0	GA_3 (0 PPM)	81.25	86.46	83.85	5.52	5.85	5.69	4.56	4.89	4.73	216.73	208.62	212.67
G_1	GA_3 (50 PPM)	85.69	90.93	88.31	5.69	6.09	5.89	4.69	5.11	4.90	231.01	224.53	227.77
G_2	GA_3 (100 PPM)	83.64	88.80	86.22	5.61	5.98	5.80	4.64	4.94	4.79	225.00	217.30	221.15
	S.Em±	0.09	0.10	0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.46	0.65	0.48
	C.D. (P 0.05) level	0.26	0.30	0.18	0.02	0.02	0.03	0.02	0.03	0.03	1.32	1.85	1.33
N_0	NAA (0 PPM)	78.11	83.11	80.61	5.41	5.71	5.56	4.51	4.84	4.68	206.28	196.60	201.44
N_1	NAA (50 PPM)	85.74	91.07	88.41	5.69	6.07	5.88	4.67	5.02	4.85	230.82	224.69	227.76
N_2	NAA (100 PPM)	86.73	92.01	89.37	5.73	6.14	5.94	4.70	5.08	4.89	235.63	229.16	232.40
	S.Em±	0.09	0.10	0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.46	0.65	0.48
	C.D. (P 0.05) level	0.26	0.30	0.18	0.02	0.02	0.03	0.02	0.03	0.03	1.32	1.85	1.33

Table.4 Interaction effect of different doses of sulphur, GA_3 and NAA on yield traits and yield

reat. Symb.	Treatments	Fresh weight of bulb (g)			Polar diameter of bulb (cm)			Equatorial diameter of bulb (cm)			Bulb yield ha^{-1} (q)		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
$S_0G_0N_0$	S (0 Kg/ha) G (0ppm) N(0ppm)	70.00	75.00	72.50	5.05	5.35	5.20	4.12	4.42	4.27	179.50	169.91	174.71
$S_0G_0N_1$	S (0 Kg/ha) G (0ppm) N(50ppm)	73.70	79.03	76.37	5.21	5.51	5.36	4.30	4.60	4.45	192.81	183.21	188.01
$S_0G_0N_2$	S (0 Kg/ha) G (0ppm) N(100ppm)	74.57	79.57	77.07	5.25	5.55	5.40	4.34	4.64	4.49	199.67	190.06	194.87
$S_0G_1N_0$	S (0 Kg/ha) G (50ppm) N(0ppm)	73.37	78.37	75.87	5.17	5.47	5.32	4.26	4.56	4.41	185.95	177.04	181.50
$S_0G_1N_1$	S (0 Kg/ha) G (50ppm) N(50ppm)	76.77	81.77	79.27	5.33	5.63	5.48	4.49	4.79	4.64	213.65	205.42	209.54
$S_0G_1N_2$	S (0 Kg/ha) G(50ppm)N(100ppm)	77.77	82.77	80.27	5.36	5.66	5.51	4.55	4.85	4.70	214.62	206.39	210.50
$S_0G_2N_0$	S (0 Kg/ha) G (100ppm) N(0ppm)	72.23	77.23	74.73	5.12	5.42	5.27	4.22	4.52	4.37	182.53	173.61	178.07
$S_0G_2N_1$	S (0 Kg/ha) G(100ppm)N(50ppm)	74.93	79.93	77.43	5.28	5.58	5.43	4.39	4.69	4.54	205.84	196.92	201.38
$S_0G_2N_2$	S(0 Kg/ha)G(100ppm)N(100ppm)	75.57	80.57	78.07	5.31	5.61	5.46	4.46	4.76	4.61	208.92	200.01	204.47
$S_1G_0N_0$	S(20 Kg/ha)G (0ppm)N(0ppm)	78.73	83.73	81.23	5.41	5.71	5.56	4.55	4.85	4.70	215.02	204.74	209.88
$S_1G_0N_1$	S (20 Kg/ha) G (0ppm) N(50ppm)	85.27	90.60	87.93	5.77	6.07	5.92	4.73	5.03	4.88	228.29	218.01	223.15
$S_1G_0N_2$	S(20 Kg/ha)G (0ppm) N(100ppm)	86.67	91.67	89.17	5.77	6.07	5.92	4.73	5.03	4.88	234.23	223.94	229.08
$S_1G_1N_0$	S(20 Kg/ha) G (50ppm) N(0ppm)	81.33	86.33	83.83	5.59	5.89	5.74	4.70	5.00	4.85	217.08	208.17	212.63
$S_1G_1N_1$	S(20 Kg/ha)G (50ppm) N(50ppm)	90.00	95.00	92.50	5.83	6.13	5.98	4.81	5.11	4.96	243.00	234.09	238.54
$S_1G_1N_2$	S(20 Kg/ha)G(50ppm)N(100ppm)	90.67	95.67	93.17	5.89	6.19	6.04	4.81	5.11	4.96	243.69	234.77	239.23
$S_1G_2N_0$	S (20 Kg/ha)G(100ppm) N(0ppm)	80.00	85.00	82.50	5.50	5.80	5.65	4.69	4.99	4.84	216.40	206.80	211.60
$S_1G_2N_1$	S(20 Kg/ha)G(100ppm)N(50ppm)	87.33	92.33	89.83	5.77	6.07	5.92	4.76	5.06	4.91	234.50	224.90	229.70
$S_1G_2N_2$	S(20Kg/ha)G(100ppm)N(100ppm)	88.00	93.00	90.50	5.80	6.10	5.95	4.77	5.07	4.92	242.86	233.26	238.06
$S_2G_0N_0$	S (40 Kg/ha) G (0ppm) N(0ppm)	79.33	84.33	81.83	5.43	5.73	5.58	4.63	4.93	4.78	215.57	205.29	210.43
$S_2G_0N_1$	S (40 Kg/ha) G (0ppm) N(50ppm)	91.00	96.67	93.83	5.91	6.29	6.10	4.81	5.19	5.00	241.77	240.08	240.92
$S_2G_0N_2$	S(40 Kg/ha) G (0ppm) N(100ppm)	92.00	97.50	94.75	5.91	6.37	6.14	4.85	5.32	5.09	243.69	242.31	243.00
$S_2G_1N_0$	S (40 Kg/ha) G (50ppm) N(0ppm)	84.67	89.67	87.17	5.75	6.05	5.90	4.73	5.28	5.00	223.94	213.65	218.80
$S_2G_1N_1$	S(40 Kg/ha) G (50ppm) N(50ppm)	98.00	104.00	101.00	6.11	6.83	6.47	4.90	5.53	5.22	266.18	264.81	265.49
$S_2G_1N_2$	S(40 Kg/ha)G(50ppm) N(100ppm)	98.67	104.83	101.75	6.17	6.97	6.57	4.93	5.73	5.33	270.97	276.46	273.72
$S_2G_2N_0$	S(40 Kg/ha) G (100ppm) N(0ppm)	83.33	88.33	85.83	5.67	5.97	5.82	4.72	5.02	4.87	220.51	210.23	215.37
$S_2G_2N_1$	S(40 Kg/ha)G(100ppm) N(50ppm)	94.67	100.33	97.50	5.99	6.54	6.26	4.87	5.17	5.02	251.37	254.80	253.08
$S_2G_2N_2$	S(40Kg/ha)G(100ppm)N(100ppm)	96.67	102.50	99.58	6.10	6.73	6.42	4.89	5.19	5.04	262.06	255.20	258.63
	S.Em±	0.27	0.31	0.20	0.01	0.02	0.03	0.01	0.03	0.03	1.39	1.94	1.44
	C.D. (P 0.05) level	0.78	0.91	0.57	0.04	0.05	0.09	0.04	0.08	0.09	3.95	5.52	4.00

Foliar application of NAA @ 100 PPM (N_2) resulted in significantly maximum 235.63, 229.16 and 232.40 q/ha bulb yield followed by N_1 (NAA @50 ppm) while, it was observed lowest 206.28, 196.60 and 201.44 q/ha in treatment N_0 (NAA 0 PPM) at first year, second year and in pooled, respectively. The results of the present investigation are in accordance with the observations of Bose *et al.,* (2009), Singh *et al.,* (2014), Pratap *et al.,* (2017) and Meena *et al.,* (2017). The increase in the fresh weight of bulb, polar and equatorial diameter of bulb and bulb yield mainly attributed to bigger bulb formation, more number of leaves, higher dry matter accumulation. Manipulation of source (leaf) and sink (bulb) relationship through the above treatments may be the principal reason for yield improvement. Higher yield in onion has so far been achieved mainly through the judicious applications of various plant growth regulators.

Interaction effect of Sulphur, GA_3 and NAA on yield and yield parameters

It is obvious from the Table 4 that the significantly maximum 98.67, 104.83 and 101.75 g fresh weight of bulb were recorded in treatment combination $S_2G_1N_2$ (S 40 Kg/ha+ GA_3 50ppm+ NAA100ppm) followed by $S_2G_1N_1$ (S 40 Kg/ha+ GA_3 50ppm+ NAA50ppm) (98.0, 104.0 and 101.0 g), while, it was recorded lowest 70.0, 75.0 and 72.50 g in treatment $S_0G_0N_0$ (S 0 Kg/ha+ GA_3 0ppm+ NAA 0ppm) at first year, second year and in pooled, respectively. Similarly the significantly maximum 6.17, 6.97 and 6.57 cm polar diameter of bulb were recorded in treatment combination $S_2G_1N_2$ (S 40 Kg/ha+ GA_3 50ppm+ NAA100ppm) followed by $S_2G_1N_1$ (S 40 Kg/ha+ GA_3 50ppm+ NAA50ppm) (6.11, 6.83 and 6.47 cm), while, it was recorded lowest 5.05, 5.35 and 5.20 cm in treatment $S_0G_0N_0$ (S 0 Kg/ha+ GA_3 0ppm+ NAA 0ppm) at first year, second year and in pooled, respectively. Results of the present investigation are also in confirmatory with the findings of Rashid (2010). Significantly maximum 4.93, 5.73 and 5.33 cm equatorial diameter of bulb were recorded in treatment combination $S_2G_1N_2$ (S 40 Kg/ha+ GA_3 50ppm+ NAA100ppm) followed by $S_2G_1N_1$ (S 40 Kg/ha+ GA_3 50ppm+ NAA50ppm) (4.90, 5.53 and 5.22 cm), while, it was recorded lowest 4.12, 4.42 and 4.27 cm in treatment $S_0G_0N_0$ (S 0 Kg/ha+ GA_3 0ppm+ NAA 0ppm) at first year, second year and in pooled, respectively. Significantly maximum 270.97, 276.46 and 273.72 q/ha bulb yield were recorded in treatment combination $S_2G_1N_2$ (S 40 Kg/ha+ GA_3 50ppm+ NAA100ppm) followed by $S_2G_1N_1$ (S 40 Kg/ha+ GA_3 50ppm+ NAA50ppm) (266.18, 264.81 and 265.49 q/ha), while, it was recorded lowest 179.50, 169.91 and 174.71 q/ha in treatment $S_0G_0N_0$ (S 0 Kg/ha+ GA_3 0ppm+ NAA 0ppm) at first, second year and pooled, respectively. The results of the present investigation are in accordance with the findings of Rashid (2010), Sitapara *et al.,* (2011), Trivedi and Dhumal (2017) and Meena *et al.,* (2017). The increase in the fresh weight of bulb, polar and equatorial diameter of bulb and bulb yield mainly attributed to more number of leaves, higher dry matter accumulation. Manipulation of source (leaf) and sink (bulb) relationship through the above treatments may be the principal reason for yield improvement. Higher yield in onion has so far been achieved mainly through the judicious applications of various plant growth regulators and sulphur.

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