International Journal of Chemical Studies 2019; 7(1): 1737-1742

International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(1): 1737-1742

Received: 15-11-2018
Accepted: 20-12-2018

Lal Singh
Ph.D Scholar, College of Agriculture, Rajmata Vijyaraje Sciendia Krishi Vishwa Vidhyalaya, Gwalior, Madhya Pradesh, India

AK Barholia
Professor (Horti) / Depty Registrar (Estt.) RVSKVV, College of Agriculture, Rajmata Vijyaraje Sciendia Krishi Vishwa Vidhyalaya, Gwalior, Madhya Pradesh, India

PKS Gurjar
Scientist (Horticulture), College of Agriculture, Rajmata Vijyaraje Sciendia Krishi Vishwa Vidhyalaya, Gwalior, Madhya Pradesh, India

Rajesh Lekhi
Professor & Head, College of Agriculture, Rajmata Vijyaraje Sciendia Krishi Vishwa Vidhyalaya, Gwalior, Madhya Pradesh, India

Jitendra Gurjar
BTM Distt. Chhatarpur, College of Agriculture, Rajmata Vijyaraje Sciendia Krishi Vishwa Vidhyalaya, Gwalior, Madhya Pradesh, India

Correspondence
Lal Singh
Ph.D Scholar, College of Agriculture, Rajmata Vijyaraje Sciendia Krishi Vishwa Vidhyalaya, Gwalior, Madhya Pradesh, India

Influence of exogenous application of Sulphur, Gibberellic acid and NAA on yield and quality of *Kharif* onion (*Allium cepa* L.) Cultivar N – 53

Lal Singh, AK Barholia, PKS Gurjar, Rajesh Lekhi and Jitendra Gurjar

Abstract

The present investigation entitled "Influence of exogenous application of Sulphur, Gibberellic acid and NAA on yield and quality of *Kharif* onion (*Allium cepa* L.) c.v N - 53" was carried out during *kharif* 2016 – 17 (first year), 2017 – 18 (second year) and in pooled 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 revealed that the application of 40 kg S ha^{-1} recorded significantly maximum quality marketable bulb percent (97.24), moisture content (87.26)percent, TSS (13.46) percent, fresh weight of bulb (93.69) and bulb yield (242.16) q per hactare whereas, splitted bulb percent was noted minimum in this treatment as compared to control. Foliar application of GA_3 @ 50ppm (G_1) and NAA @ 100 PPM (N_2) exhibited significantly highest marketable bulb per cent, moisture content percent, TSS percent ,fresh weight of bulb and bulb yield per hectare while, splitted bulb percent was noted minimum in this treatment as compared to control. Interaction effect was also observed same trend. The cost benefit ratio 1: 3.67 was found maximum with the application of S 40 Kg/ha+ GA_3 50 ppm + NAA100 ppm ($S_2G_1N_2$) it also recorded maximum bulb yield of 290.18 q ha^{-1} and net return of Rs 2,11,139 ha^{-1} in onion variety N - 53. From the study it can be concluded that various yield and quality and parameters were improved with the application of S 40 Kg/ha+ GA_3 50 ppm + NAA 100ppm and it was economically viable and treatment.

Keywords: kharif onion, sulphur, Gibberellic acid, NAA, yield, quality and economics

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 markets 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.

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 onion. 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 and a significant reduction of catalyses activities at all age. The excessive vegetative growth is a problem in *kharif* onion. The plant height goes up to one meter and neck of plant become thick, while, the bulb remains small. This is due to poor translocation of assimilates from leaves to bulbs. This translocation of food materials or for altering source to sink relationship is changed by application of plant growth regulators. Gibberellic acid has been reported to influence seed germination, stem growth, root growth, adventitious root formation and juvenility in many vegetable crops. It stimulates cell division and elongation, germination of seeds, prevention of genetic dwarfism, dormancy and extending shelf life. Naphthalene Acetic Acid (NAA) play key role in cell elongation, cell division, vascular tissue differentiation, root initiation, apical dominance, leaf senescence, leaf and fruit abscission (Davies, 1987) [2]. It is a wide broad, somatotrophin-like growth regulator in plants. It produces significant effects in promoting development of pointed ends for the root system, resulting in more, straighter and thicker roots. Hence, in this study, attempts were made to identity the influence of exogenous application of sulphur, Gibberellic acid and NAA on yield, quality and economics of kharif onion (*Allium cepa* L.)

Materials and Methods

The present investigation entitled "Influence of exogenous application of Sulphur, Gibberellic acid and NAA on yield and quality of *Kharif* onion (*Allium cepa* L.) c.v N - 53" was carried out during *kharif* 2016 – 17 (first year) and 2017 – 18 (second year) and in pooled at the Experimental field, Krishi Vigyan Kendra, Rajgarh (M.P.). The experimental material for the present investigation 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 100 ppm and three levels of NAA i.e. 0, 50 and 100 PPM. The foliar spray of plant growth regulators a.i. GA_3 and NAA @ 50 and 100 ppm was done at seedling stage and 30 DAT. Experiments were laid out in Factorial Randomized Complete Block Design with three replications. Present study was conducted to determine the effect of sulphur, gibberellic acid and NAA levels on yield, quality of *Kharif* onion production. Observations were recorded on the basis of five random competitive plants selected from each treatment separately for yield and quality parameters were evaluated as per standard procedure and economics of the treatments were worked out. The experimental plants were regularly observed and the data were recorded on splitted bulb (%), marketable bulb (%), moisture content (%), TSS (%), fresh weight of bulb and bulb yield per hectare. The pooled basis analysis was also performed to a certain the influences of the treatment.

Results and Discussion

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}), 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). Similar results have also been reported by Suman *et al.* (2002) [15], Rashid (2010) [11], Jain *et al.* (2014) [6] and El Sayed *et al.* (2015) [3]. The application of treatment S_2 (40kg S ha^{-1}) 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. The increase in fresh weight of bulb and Similar results were also reported in onion crop by Suman *et al.* (2002) [15], Rashid (2010) [11], 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 is 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 Sulphur on quality parameters

The treatment S_2 (40kg S ha^{-1}) recorded significantly minimum 4.11, 4.54 and 4.33 % splitted bulb and it was noted highest 11.80, 12.50 and 12.15 % in treatment S_0 (0 kg S ha^{-1}) at first year, second year and in pooled, respectively. Similar results were also reported by Rashid (2010) [11]. Treatment S_2 (40kg S ha^{-1}) recorded significantly maximum 96.85, 97.53 and 97.24 % marketable bulb and it was noted minimum 94.0, 94.44 and 94.22 % in treatment S_0 (0 kg S ha^{-1}) in first year, second year and in pooled, respectively. The marketable bulb percentage was increase with the application of higher levels of S might be due to increased uptake of N, P, K and S by crop which might have enhanced the synthesis and translocation of photosynthesis to the bulbs and which lead to increase size and quality. Similar results were also reported in onion crop by Kukanoor *et al.* (2006) [8] and El-Tantawy and El-Beik (2009) [4]. The treatment S_2 (40kg S ha^{-1}) was recorded significantly maximum 85.06, 89.47 and 87.26 % moisture content and it was noted minimum 80.82, 85.30 and 83.06 % in treatment S_0 (0 kg S ha^{-1}) in first year, second year and in pooled, respectively. The application of treatment S_2 (40kg S ha^{-1}) was recorded significantly maximum 13.31, 13.61 and 13.46 % TSS and it was noted minimum 11.03, 11.53 and 11.28 % in treatment S_0 (0 kg S ha^{-1}) in first, second year and pooled, respectively. The application of sulphur might have enhanced the availability of minerals and accumulation of soluble solids in onion bulbs which resulted in more total soluble solid. These findings are also in agreement with the findings of Jain *et al.* (2014) [6] and El Sayed *et al.* (2015) [3].

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, while, it was recorded lowest 81.25, 86.46 and 83.85 g 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) [11], Govind *et al.* (2015) [5], Yadagiri *et al.* (2018) and Thakur *et al.* (2018) [11]. Foliar application of GA_3 @ 50ppm (G_1) was exhibited significantly maximum 231.01, 224.53 and 227.77 q/ha bulb yield, while, 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. Fresh weight 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 GA_3 on quality parameters

Treatment G_1 (50ppm) exhibited significantly lowest 6.58, 7.15 and 6.87 % splitted bulb, while, it was recorded highest 8.69, 9.35 and 8.02 % 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) [11]. The treatment G_1 (50ppm) exhibited significantly highest 96.05, 96.59 and 96.32% marketable bulb, while, it was recorded lowest 95.28, 95.72 and 95.50 % marketable bulb in treatment G_0 (0 ppm i.e. control) in first, second year and pooled, respectively. This might be due to better translocation of photosynthates diversified toward source to newly developed sink, which could be supported by heavier build up of sufficient food reserves in the developing pods in the physiologically active plant due to spraying of growth regulators. The GA_3, treatment G_1 (50ppm) was exhibited significantly highest 83.74, 88.12 and 85.93% moisture content, while, it was recorded lowest 82.76, 87.13 and 84.94 % moisture content in treatment G_0 (0 ppm i.e. control) in first year, second year and in pooled, respectively. Foliar application of GA_3 @ 50ppm (G_1) exhibited significantly highest 12.63, 13.02 and 12.83% TSS, while, it was recorded lowest 12.09, 12.56 and 12.33 %

TSS in treatment G_0 (0 ppm i.e. control) in first year, second year and in pooled, respectively. Improving on nutritive value of onion bulb by GA_3 application may be due to the role of gibberellins on improving plant growth, photosynthetic and remain physiologically more active to build up of sufficient food reserves. Also, increased growth and development due to exogenous application of growth regulators may be attributed to enhanced cell division, increased carbohydrate hydrolysis and cell wall plasticity. These results are in accordance with the finding of Govind *et al.* (2015) [5].

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), 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. Results of the present investigation also in conformity with the findings of Bose *et al.* (2009) [1], Singh *et al.* (2014) [13], Pratap *et al.* (2017) [10]. Foliar application of NAA @ 100 PPM (N_2) was noticed significantly maximum 235.63, 229.16 and 232.40 q/ha bulb yield, 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) [1], Singh *et al.* (2014) [13], Pratap *et al.* (2017) [10] and Meena *et al.* (2017) [9]. The increase in the fresh weight 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.

Effect of NAA on quality parameters

Significantly lowest 6.05, 6.53 and 6.29 % splitted bulb was noticed under the treatment N_2 (NAA 100 PPM), while, it was observed maximum 10.35, 11.09 and 10.72 % in treatment N_0 (NAA 0 PPM) at first year, second year and in pooled, respectively. Significantly maximum 96.21, 96.75 and 96.48 % marketable bulb was noticed under the treatment N_2 (NAA 100 PPM), while, it was observed minimum 94.79, 95.22 and 95.01 % in treatment N_0 (NAA 0 PPM) in first year, second year and in pooled, respectively. This might be due to better translocation of photosynthetic diversified toward source to newly developed sink, which could be supported by heavier build up of sufficient food reserves in the developing bulbs in the physiologically active plant due to spraying of growth regulators. The treatment N_2 (NAA 100 PPM) was noticed significantly maximum 84.01, 88.44 and 86.22 % moisture content while, it was observed minimum 81.90, 86.27 and 84.09 % in treatment N_0 (NAA 0 PPM) in first, second year and pooled, respectively. Significantly maximum 12.81, 13.20 and 13.0 % TSS was noticed under the treatment N_2 (NAA 100 PPM), while, it was observed minimum 11.58, 12.08 and 11.83 % in treatment N_0 (NAA 0 PPM) in first year, second year and in pooled, respectively. This effect might be due to influence of these substances on enzymatic activity and translocation of the metabolites to onion bulb. These results are agreement with those obtained by Pratap *et al.* (2017) [10].

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. Results of the present investigation was also in confirmatory with the findings of Rashid (2010) [11] and Sitapara *et al*. (2011) [14]. 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 year, second year and in pooled, respectively. The results of the present investigation are in accordance with the observations of Rashid (2010) [11], Sitapara *et al*. (2011) [14] and Meena *et al*. (2017) [9]. The increase in the fresh weight 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.

Interaction effect of Sulphur, GA_3 and NAA on quality parameters

Results revealed that the interaction effect significantly lowest 0.26, 0.46 and 0.36 % splitted 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) (0.67, 0.82 and 0.74%), while, it was recorded maximum 14.67, 15.50 and 15.08% in treatment $S_0G_0N_0$ (S 0 Kg/ha+ GA_3 0ppm+ NAA 0ppm) at first year, second year and in pooled, respectively. Similar results were also reported by Rashid (2010) [11]. Maximum 98.25, 99.19 and 98.72 % marketable 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+ NAA 50ppm) (98.04, 98.88 and 98.46%), while, it was recorded minimum 93.28, 93.72 and 93.50 % marketable bulb in treatment $S_0G_0N_0$ (S 0 Kg/ha+ GA_3 0ppm+ NAA 0ppm) in first year, second year and in pooled, respectively. The cumulative effects on marketable bulb percentage was increase with the application of higher levels of S might be due to increased uptake of N, P, K and S by crop which might have enhanced the synthesis and translocation of photosynthesis to the bulbs and which leads to increase size and quality. The influence of application of growth regulators might be due to better translocation of photosynthesis diversified toward source to newly developed sink, which could be supported by heavier build up of sufficient food reserves in the developing bulbs in the physiologically active plant. Maximum 86.51, 90.81 and 88.66 % moisture content 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+ NAA 50ppm) (86.34, 90.79 and 88.57%), while, it was recorded minimum 80.06, 82.33 and 81.19 % moisture content in treatment $S_0G_0N_0$ (S 0 Kg/ha+ GA_3 0ppm+ NAA 0ppm) in first year, second year and in pooled, respectively. Similarly the maximum 14.08, 14.28 and 14.18 % TSS were recorded in treatment combination $S_2G_1N_2$ (S 40 Kg/ha+ GA_3 50 ppm + NAA100ppm) followed by

$S_2G_1N_1$ (S 40 Kg/ha+ GA_3 50ppm+ NAA 50 ppm) (14.05, 14.13 and 14.09%), while, it was recorded minimum 10.23, 10.73 and 10.48 % TSS in treatment $S_0G_0N_0$ (S 0 Kg/ha+ GA_3 0ppm+ NAA 0ppm) in first year, second year and in pooled, respectively. These results are agreement with those obtained by Kotecha *et al.* (2016) [7].

Economics of the treatments

Higher money value and less cost of cultivation are desirable traits for getting higher returns. It is clear from the Table 5 that the significantly maximum bulb yield of 290.18 q ha^{-1} was obtained in onion variety N - 53 under the treatment $S_2G_1N_2$ (S 40 Kg/ha+ GA_3 50ppm + NAA100ppm) and it was gave maximum net return of Rs 2,11,139 ha^{-1} and cost benefit ratio 1: 3.67 followed by the treatment $S_2G_1N_1$ (S 40 Kg/ha+ GA_3 50ppm+ NAA 50ppm) which exhibited the bulb yield 273.38 q ha^{-1} along with net return of Rs 1,94,438 ha^{-1} and cost benefit ratio 1: 3.46 in pooled. However, the lower bulb yield of 174.36 q ha^{-1}, net return of Rs 99,366 ha^{-1} and cost benefit ratio 1: 2.32 was noted in $S_0G_0N_0$ (S 0 Kg/ha+ GA_3 0ppm+ NAA 0ppm) but lowest net return of Rs 98,426 ha^{-1} and cost benefit ratio 1: 2.25 was obtained in treatment $S_0G_2N_0$ (S 0 Kg/ha+ GA_3 100ppm+ NAA 0ppm) due to higher cost of cultivation Rs 78,954 ha^{-1}. These results are agreement with those obtained by Suman *et al.* (2002) [15], Bose *et al.* (2009) [1], Singh *et al.* (2016) [12] and Meena *et al.* (2017) [9].

Table 1: Effect of different doses of sulphur, GA_3 and NAA on quality

Treat. Symb.	Treatments	Splitted bulb (%)			Marketable bulb (%)			Moisture content (%)		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
S_0	Sulphur (0 kg/ha)	11.80	12.50	12.15	94.00	94.44	94.22	80.82	85.30	83.06
S_1	Sulphur (20 kg/ha)	7.14	7.81	7.48	96.06	96.50	96.28	83.87	88.19	86.03
S_2	Sulphur (40 kg/ha)	4.11	4.54	4.33	96.85	97.53	97.24	85.06	89.47	87.26
	S.Em±	0.07	0.08	0.05	0.19	0.28	0.15	0.42	0.34	0.24
	C.D. (P 0.05) level	0.21	0.22	0.14	0.55	0.80	0.43	1.19	0.96	0.68
G_0	GA_3 (0 PPM)	8.69	9.35	8.02	95.28	95.72	95.50	82.76	87.13	84.94
G_1	GA_3 (50 PPM)	6.58	7.15	6.87	96.05	96.59	96.32	83.74	88.12	85.93
G_2	GA_3 (100 PPM)	7.78	8.36	8.07	95.68	96.15	95.92	83.24	87.72	85.48
	S.Em±	0.07	0.08	0.05	0.19	0.28	0.15	0.42	0.34	0.24
	C.D. (P 0.05) level	0.21	0.22	0.14	0.55	N.S.	0.43	N.S.	N.S.	0.68
N_0	NAA (0 PPM)	10.35	11.09	10.72	94.79	95.22	95.01	81.90	86.27	84.09
N_1	NAA (50 PPM)	6.66	7.23	6.94	96.01	96.49	96.25	83.83	88.24	86.04
N_2	NAA (100 PPM)	6.05	6.53	6.29	96.21	96.75	96.48	84.01	88.44	86.22
	S.Em±	0.07	0.08	0.05	0.19	0.28	0.15	0.42	0.34	0.24
	C.D. (P 0.05) level	0.21	0.22	0.14	0.55	0.80	0.43	1.19	0.96	0.68

Table 2: Interaction effect of different doses of sulphur, GA_3 and NAA on quality

Treat. Symb.	Treatments	Splitted bulb (%)			Marketable bulb (%)			Moisture content (%)		
		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)	14.67	15.50	15.08	93.28	93.72	93.50	80.06	82.33	81.19
$S_0G_0N_1$	S (0 Kg/ha) G (0ppm) N(50ppm)	12.23	12.97	12.60	93.91	94.35	94.13	80.75	85.71	83.23
$S_0G_0N_2$	S (0 Kg/ha) G (0ppm) N(100ppm)	11.67	12.27	11.97	94.01	94.45	94.23	80.83	85.79	83.31
$S_0G_1N_0$	S (0 Kg/ha) G (50ppm) N(0ppm)	13.03	13.87	13.45	93.74	94.17	93.95	80.55	85.22	82.89
$S_0G_1N_1$	S (0 Kg/ha) G (50ppm) N(50ppm)	9.67	10.44	10.05	94.56	95.00	94.78	81.19	86.02	83.61
$S_0G_1N_2$	S (0 Kg/ha) G(50ppm)N(100ppm)	9.33	9.93	9.63	94.67	95.11	94.89	81.43	85.85	83.64
$S_0G_2N_0$	S (0 Kg/ha) G (100ppm) N(0ppm)	13.57	14.33	13.95	93.42	93.86	93.64	80.48	85.30	82.89
$S_0G_2N_1$	S (0 Kg/ha) G(100ppm)N(50ppm)	11.33	12.00	11.67	94.13	94.57	94.35	80.88	85.47	83.18
$S_0G_2N_2$	S(0 Kg/ha)G(100ppm)N(100ppm)	10.67	11.23	10.95	94.27	94.71	94.49	81.19	86.01	83.60
$S_1G_0N_0$	S(20 Kg/ha)G (0ppm)N(0ppm)	9.33	10.17	9.75	94.67	95.11	94.89	81.44	86.73	84.09
$S_1G_0N_1$	S (20 Kg/ha) G (0ppm) N(50ppm)	7.33	8.06	7.70	96.25	96.68	96.46	84.01	88.16	86.09
$S_1G_0N_2$	S(20 Kg/ha)G (0ppm) N(100ppm)	7.00	7.63	7.32	96.30	96.74	96.52	84.25	88.16	86.21
$S_1G_1N_0$	S(20 Kg/ha) G (50ppm) N(0ppm)	8.60	9.33	8.97	95.73	96.16	95.94	83.15	87.62	85.38
$S_1G_1N_1$	S(20 Kg/ha)G (50ppm) N(50ppm)	5.67	6.27	5.97	96.64	97.08	96.86	85.33	89.43	87.38
$S_1G_1N_2$	S(20 Kg/ha)G(50ppm)N(100ppm)	4.33	4.90	4.61	96.84	97.28	97.06	85.52	89.75	87.64
$S_1G_2N_0$	S (20 Kg/ha)G(100ppm) N(0ppm)	9.00	9.77	9.38	95.22	95.65	95.43	82.23	86.87	84.55
$S_1G_2N_1$	S(20 Kg/ha)G(100ppm)N(50ppm)	6.67	7.30	6.99	96.34	96.77	96.55	84.37	88.24	86.30
$S_1G_2N_2$	S(20Kg/ha)G(100ppm)N(100ppm)	6.33	6.90	6.62	96.55	96.99	96.77	84.49	88.74	86.62
$S_2G_0N_0$	S (40 Kg/ha) G (0ppm) N(0ppm)	9.00	9.63	9.32	95.03	95.47	95.25	82.12	87.09	84.61
$S_2G_0N_1$	S (40 Kg/ha) G (0ppm) N(50ppm)	3.67	4.22	3.94	96.97	97.41	97.19	85.69	90.09	87.89
$S_2G_0N_2$	S(40 Kg/ha) G (0ppm) N(100ppm)	3.33	3.73	3.53	97.06	97.51	97.28	85.73	90.07	87.90
$S_2G_1N_0$	S (40 Kg/ha) G (50ppm) N(0ppm)	7.67	8.33	8.00	96.02	96.45	96.23	83.63	87.57	85.60
$S_2G_1N_1$	S(40 Kg/ha) G (50ppm) N(50ppm)	0.67	0.82	0.74	98.04	98.88	98.46	86.34	90.79	88.57
$S_2G_1N_2$	S(40 Kg/ha)G(50ppm) N(100ppm)	0.26	0.46	0.36	98.25	99.19	98.72	86.51	90.81	88.66
$S_2G_2N_0$	S(40 Kg/ha) G (100ppm) N(0ppm)	8.25	8.92	8.58	95.99	96.42	96.20	83.44	87.74	85.59
$S_2G_2N_1$	S(40 Kg/ha)G(100ppm) N(50ppm)	2.67	3.02	2.84	97.21	97.67	97.44	85.95	90.26	88.11
$S_2G_2N_2$	S(40Kg/ha)G(100ppm)N(100ppm)	1.50	1.73	1.62	97.97	98.74	98.35	86.12	90.81	88.46

	S.Em±	0.21	0.23	0.14	0.58	0.84	0.46	1.25	1.02	0.73
	C.D. (P 0.05) level	N.S.	N.S.	0.41	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 3: Effect of different doses of sulphur, GA_3 and NAA on quality

Treat. Symb.	Treatments	TSS (%)			Fresh weight of bulb (g)			Bulb yield ha^{-1} (q)		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
S_0	Sulphur (0 kg/ha)	11.03	11.53	11.28	74.32	79.36	76.84	198.17	189.17	193.67
S_1	Sulphur (20 kg/ha)	12.74	13.24	12.99	85.33	90.37	87.85	230.56	220.96	225.76
S_2	Sulphur (40 kg/ha)	13.31	13.61	13.46	90.93	96.46	93.69	244.01	240.31	242.16
	S.Em±	0.13	0.14	0.08	0.09	0.10	0.06	0.46	0.65	0.48
	C.D. (P 0.05) level	0.38	0.39	0.24	0.26	0.30	0.18	1.32	1.85	1.33
G_0	GA_3 (0 PPM)	12.09	12.56	12.33	81.25	86.46	83.85	216.73	208.62	212.67
G_1	GA_3 (50 PPM)	12.63	13.02	12.83	85.69	90.93	88.31	231.01	224.53	227.77
G_2	GA_3 (100 PPM)	12.36	12.79	12.58	83.64	88.80	86.22	225.00	217.30	221.15
	S.Em±	0.13	0.14	0.08	0.09	0.10	0.06	0.46	0.65	0.48
	C.D. (P 0.05) level	0.38	N.S.	0.24	0.26	0.30	0.18	1.32	1.85	1.33
N_0	NAA (0 PPM)	11.58	12.08	11.83	78.11	83.11	80.61	206.28	196.60	201.44
N_1	NAA (50 PPM)	12.68	13.10	12.89	85.74	91.07	88.41	230.82	224.69	227.76
N_2	NAA (100 PPM)	12.81	13.20	13.00	86.73	92.01	89.37	235.63	229.16	232.40
	S.Em±	0.13	0.14	0.08	0.09	0.10	0.06	0.46	0.65	0.48
	C.D. (P 0.05) level	0.38	0.39	0.24	0.26	0.30	0.18	1.32	1.85	1.33

Table 4: Interaction effect of different doses of sulphur, GA_3 and NAA on quality

Treat. Symb.	Treatments	TSS (%)			Fresh weight of bulb (g)			Bulb yield ha^{-1} (q)		
		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)	10.23	10.73	10.48	70.00	75.00	72.50	179.50	169.91	174.71
$S_0G_0N_1$	S (0 Kg/ha) G (0ppm) N(50ppm)	10.93	11.43	11.18	73.70	79.03	76.37	192.81	183.21	188.01
$S_0G_0N_2$	S (0 Kg/ha) G (0ppm) N(100ppm)	11.02	11.52	11.27	74.57	79.57	77.07	199.67	190.06	194.87
$S_0G_1N_0$	S (0 Kg/ha) G (50ppm) N(0ppm)	10.76	11.26	11.01	73.37	78.37	75.87	185.95	177.04	181.50
$S_0G_1N_1$	S (0 Kg/ha) G (50ppm) N(50ppm)	11.57	12.07	11.82	76.77	81.77	79.27	213.65	205.42	209.54
$S_0G_1N_2$	S (0 Kg/ha) G(50ppm)N(100ppm)	11.70	12.20	11.95	77.77	82.77	80.27	214.62	206.39	210.50
$S_0G_2N_0$	S (0 Kg/ha) G (100ppm) N(0ppm)	10.56	11.06	10.81	72.23	77.23	74.73	182.53	173.61	178.07
$S_0G_2N_1$	S (0 Kg/ha) G(100ppm)N(50ppm)	11.07	11.57	11.32	74.93	79.93	77.43	205.84	196.92	201.38
$S_0G_2N_2$	S(0 Kg/ha)G(100ppm)N(100ppm)	11.40	11.90	11.65	75.57	80.57	78.07	208.92	200.01	204.47
$S_1G_0N_0$	S(20 Kg/ha)G (0ppm)N(0ppm)	11.73	12.23	11.98	78.73	83.73	81.23	215.02	204.74	209.88
$S_1G_0N_1$	S (20 Kg/ha) G (0ppm) N(50ppm)	12.86	13.36	13.11	85.27	90.60	87.93	228.29	218.01	223.15
$S_1G_0N_2$	S(20 Kg/ha)G (0ppm) N(100ppm)	12.99	13.49	13.24	86.67	91.67	89.17	234.23	223.94	229.08
$S_1G_1N_0$	S(20 Kg/ha) G (50ppm) N(0ppm)	12.09	12.59	12.34	81.33	86.33	83.83	217.08	208.17	212.63
$S_1G_1N_1$	S(20 Kg/ha)G (50ppm) N(50ppm)	13.27	13.77	13.52	90.00	95.00	92.50	243.00	234.09	238.54
$S_1G_1N_2$	S(20 Kg/ha)G(50ppm)N(100ppm)	13.39	13.89	13.64	90.67	95.67	93.17	243.69	234.77	239.23
$S_1G_2N_0$	S (20 Kg/ha)G(100ppm) N(0ppm)	12.03	12.53	12.28	80.00	85.00	82.50	216.40	206.80	211.60
$S_1G_2N_1$	S(20 Kg/ha)G(100ppm)N(50ppm)	13.14	13.64	13.39	87.33	92.33	89.83	234.50	224.90	229.70
$S_1G_2N_2$	S(20Kg/ha)G(100ppm)N(100ppm)	13.15	13.65	13.40	88.00	93.00	90.50	242.86	233.26	238.06
$S_2G_0N_0$	S (40 Kg/ha) G (0ppm) N(0ppm)	11.93	12.43	12.18	79.33	84.33	81.83	215.57	205.29	210.43
$S_2G_0N_1$	S (40 Kg/ha) G (0ppm) N(50ppm)	13.49	13.91	13.70	91.00	96.67	93.83	241.77	240.08	240.92
$S_2G_0N_2$	S(40 Kg/ha) G (0ppm) N(100ppm)	13.63	13.96	13.79	92.00	97.50	94.75	243.69	242.31	243.00
$S_2G_1N_0$	S (40 Kg/ha) G (50ppm) N(0ppm)	12.72	13.22	12.97	84.67	89.67	87.17	223.94	213.65	218.80
$S_2G_1N_1$	S(40 Kg/ha) G (50ppm) N(50ppm)	14.05	14.13	14.09	98.00	104.00	101.00	266.18	264.81	265.49
$S_2G_1N_2$	S(40 Kg/ha)G(50ppm) N(100ppm)	14.08	14.28	14.18	98.67	104.83	101.75	270.97	276.46	273.72
$S_2G_2N_0$	S(40 Kg/ha) G (100ppm) N(0ppm)	12.20	12.71	12.46	83.33	88.33	85.83	220.51	210.23	215.37
$S_2G_2N_1$	S(40 Kg/ha)G(100ppm) N(50ppm)	13.77	14.02	13.89	94.67	100.33	97.50	251.37	254.80	253.08
$S_2G_2N_2$	S(40Kg/ha)G(100ppm)N(100ppm)	13.90	14.07	13.98	96.67	102.50	99.58	262.06	255.20	258.63
	S.Em±	0.40	0.41	0.26	0.27	0.31	0.20	1.39	1.94	1.44
	C.D. (P 0.05) level	N.S.	N.S.	N.S.	0.78	0.91	0.57	3.95	5.52	4.00

Table 5: Economics of different doses of Sulphur, GA_3 and NAA for *Kharif* onion in pooled

Treat. Symb.	Bulb yield (q ha^{-1})	Gross income (Rs/ha)*	Expenditure (Rs/ha)	Net income (Rs/ha)	C: B ratio
$S_0G_0N_0$	174.36	174360	74994	99366	1: 2.32
$S_0G_0N_1$	187.67	187670	75093	112577	1: 2.50
$S_0G_0N_2$	194.52	194520	75192	119328	1: 2.59
$S_0G_1N_0$	180.81	180810	76974	103836	1: 2.35
$S_0G_1N_1$	208.51	208510	77073	131437	1: 2.71
$S_0G_1N_2$	209.47	209470	77172	132298	1: 2.71
$S_0G_2N_0$	177.38	177380	78954	98426	1: 2.25
$S_0G_2N_1$	200.69	200690	79053	121637	1: 2.54
$S_0G_2N_2$	203.78	203780	79152	124628	1: 2.57
$S_1G_0N_0$	209.88	209880	75929	133951	1: 2.76

$S_1G_0N_1$	223.15	223150	76028	147122	1: 2.94
$S_1G_0N_2$	229.08	229080	76127	152953	1: 3.01
$S_1G_1N_0$	211.94	211940	77909	134031	1: 2.72
$S_1G_1N_1$	237.86	237860	78008	159852	1: 3.05
$S_1G_1N_2$	238.54	238540	78107	160433	1: 3.05
$S_1G_2N_0$	211.25	211250	79889	131361	1: 2.64
$S_1G_2N_1$	229.36	229360	79988	149372	1: 2.87
$S_1G_2N_2$	237.72	237720	80087	157633	1: 2.97
$S_2G_0N_0$	210.43	210430	76863	133567	1: 2.74
$S_2G_0N_1$	242.80	242800	76962	165838	1: 3.15
$S_2G_0N_2$	246.43	246430	77061	169369	1: 3.20
$S_2G_1N_0$	218.80	218800	78843	139957	1: 2.78
$S_2G_1N_1$	273.38	273380	78942	194438	1: 3.46
$S_2G_1N_2$	290.18	290180	79041	211139	1: 3.67
$S_2G_2N_0$	215.37	215370	80823	134547	1: 2.66
$S_2G_2N_1$	253.08	253080	80922	172158	1: 3.13
$S_2G_2N_2$	265.49	265490	81021	184469	1: 3.28

*Sale rate of produce was Rs 1000 ha^{-1}

References

1. Bose US, Bisen A, Sharma RK, Dongre R. Effect of micro nutrients along with growth regulator on growth and yield of onion. International Journal of Applied Agricultural Research. 2009; 4(3):267-271.
2. Davies PJ. Plant hormone and their role in plant growth and development. Martinus Nijhoff Publ. Dordrecht, Netherlands, 1987.
3. El Sayed Hameda, Abdullah EA, El-Morsy HA, Hanan Saleh Al Othaimen. The role of sulphur and certain foliar spray levels of micro-nutrients on garlic (*Allium sativum* L.) plant. Int. J Curr. Res. Biosci. Plant Biol. 2015; 2(6):76-87.
4. El-Tantawy EM, El-Beik AK. Relationship between growth, yield and storability of onion (*Allium cepa* L.) with fertilization of nitrogen, sulphur and copper under calcareous soil conditions. Research Journal of Agriculture and Biological Sciences. 2009; 5(4):361-371.
5. Govind S, Maji R, Kumawat A, Pal Kumar S, Saha S. Improvement of growth, yield and quality of garlic (*Allium sativum* L.) CV. G-282 through a novel approach. Bio Science. 2015; 10(1):23-27.
6. Jain Goldi, Kushwah SS, Singh OP, Verma KS. Effect of different doses of nitrogen and sulphur on growth, yield and quality of onion (*Allium cepa*). The Indian Journal of Agricultural Sciences. 2014; 84(11):205-208.
7. Kotecha AV, Dhruve JJ, Patel NJ, Vihol NJ. Influence of micronutrients and growth regulators on the performance of cabbage quality. Adv. Res. J Crop Improv. 2016; 7(1):46-51.
8. Kukanoor L, Basavarajan, Rokhade AK. Influence of curing methods on storability of onion. J Asian Hort. 2006; 2(4):277-281.
9. Meena Rajesh Kumar, Dhaka RS, Meena Narender Kumar, Meena Sunil. Effect of foliar application of NAA and GA_3 on growth and yield of okra [*Abelmoschus esculentus* (L.) Moench] cv. Arka Anamika. Int. J Pure App. Biosci. 2017; 5(2):1057-1062.
10. Pratap D, Padma M, Sivasankar A. Effect of plant growth regulators on yield and quality of garlic (*Allium sativum* L.) cv. Jamnagar. *Green Farming.* 2017; 8(2):444-448.
11. Rashid MHA. Effect of sulphur and GA_3 on the growth and yield of onion. Progress. Agric. 2010; 21(1&2):57-63.
12. Singh DP, Seema NV, Ali J, Singh SP, Singh V. Effect of sulphur on yield, uptake of nutrients and economics of garlic (*Allium sativum*), onion (*Allium cepa*) and potato (*Solanum tuberosum*) in alluvial soil. Indian Journal of Agricultural Sciences. 2016; 86(5):661-665.
13. Singh Harsh Deep, Maji Sutanu, Sanjay Kumar. Influence of plant bio-regulators on growth and yield of garlic (*Allium sativum* L.). International Journal of Agricultural Sciences. 2014; 10(2):546-549.
14. Sitapara HH, Vihol NJ, Patel MJ, Patel JS. Effect of growth regulators and micro nutrient on growth and yield of cauliflower cv. ‘SNOWBALL-16’. The Asian Journal of Horticulture. 2011; 6(2):348-351.
15. Suman Smriti, Rajesh Kumar, Singh SK. Effect of sulphur and boron nutrition on growth, yield and quality of onion (*Allium cepa* L.). Journal of Applied Biology. 2002; 12(1/2):40-46.
16. Thakur Omesh, Vijay Kumar, Singh Jitendra. Pruning and gibberellic acid on the growth and yield attributes of onion (*Allium cepa* L.) var Agrifond Light Red. Int. J Curr. Microbiol. App. Sci. 2018; 7(1):976-981.
17. Yadagiri Jagati, Gupta Prashant Kumar, Tiwari Rajesh, Singh VB. Improvement of growth and yield of onion (*Allium cepa* L.) cv. Agrifound Light Red through different application methods of gibberellic acid and *Trichoderma viride.* Int. J Pure App. Biosci. 2017; 5(4):1444-1450.