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Effect of micronutrients and plant growth regulator on grading of bulb, biochemical and mineral components of onion (*Allium cepa* L.) cv. GAWO-2

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Abstract
According to the high cost of applied micronutrients and growth regulators, in-depth research is required to increase their effectiveness. However, selecting the correct of micronutrients and growth regulators is crucial to ensuring higher economic productivity. The present study was conducted regarding the significance of micronutrients and growth regulators for evaluating onion production quality. The study described in a randomized block design (RBD) involved twelve different treatments, each replicated three times. The experimental results revealed that foliar application of micronutrients and plant growth regulator increased A grade bulb, B grade bulb, TSS, total soluble sugars, ascorbic acid, total phenols and total flavonoids and increase was more in treatment Zn (1 g/l) + GA_3 (100 mg/l). Also, application of micronutrients and plant growth regulator increased mineral components of bulb like P, S, Mg, Mn and Cu in treatment Zn (1 g/l) + GA_3 (100 mg/l).

Keywords: Onion, micronutrients, growth regulators

Introduction

The onion is referred to as the "Queen of Kitchen" or the "Poverty Man's Kasturi." Onion is grown in India both as a vegetable and as a medicine (Pramanik, 2018) [18]. Onion is frequently used as a cooked vegetable in soups, a mix vegetable, and as a flavoring agent in many other dishes. It can be used in both its green and mature bulb forms. It is eaten as a vegetable and a seasoning. The mature and immature bulbs, as well as the green leaves, can be cooked or eaten raw. It's an essential kitchen tool utilized to enhance the taste of a wide range of dishes. The onion is used to make a variety of homeopathic, unani, and ayurvedic medicines and has many medicinal benefits. By prevent the oxidation of low-density lipoproteins, phenolic compounds offer substantial protection against diabetes-related atherogenic effects. Different medicinal benefits can be derived from onions. It acts as a stimulant, invigorator, spicy agent, enhancer of virility, potent rejuvenator, booster of digestive enzymes, and lubricating agent. It is considered an effective remedy for heart problems, indigestion, leprosy, hemorrhoids, inflammation, and blood-related issues. An excellent vermifuge is onion juice. According to Trivedi and Dhumal (2017) [25], it is also helpful for intestinal disorders.

Application of micronutrients and growth regulator has prime importance for improving the bulb yield, export and market qualities. It can boost growth, yield and bulb quality of onion. The application of iron, boron and zinc either alone or in combination helped to increase the uptake of iron, zinc, boron, manganese and copper by vegetable crops. Zinc participates in metabolic processes and enzyme systems and is essential for the production of carbohydrates and chlorophyll. Iron aids in the absorption of other elements and functions as a catalyst in the synthesis of the chlorophyll molecule. It is one of the many enzyme cofactors and components associated with the transfer of energy, nitrogen reduction and fixation, and the synthesis of lignin. By accelerating cell elongation and cell division in the sub apical meristem region, gibberellins encourage shoot growth by lengthening internodes. Gibberellin regulates the sub apical meristem's mitotic activity.

Therefore, it is urgent to determine whether applying micronutrients along with growth-regulators during the onion crop's life cycle is effective. In light of the influence of micronutrients and growth regulators on onion yield and nutritional quality, this current study is titled “Effect of micronutrients and plant growth regulator on grading of bulb, biochemical and mineral components of onion (*Allium cepa* L.) cv. GAWO-2” was done.

Materials and Methods

A field experiment was conducted during the *rabi* seasons of the year 2019-20 and 2020-21 at the experimental farm of Main Vegetable Research Centre, Anand Agricultural University, Anand. The soil in this region is categorized as loamy sand and is referred to locally as 'Goradu' soil. The soil has available nitrogen (200.4 N kg/ha) and available phosphorus (35.40 P_2O_5 kg/ha) while available potash (256.39 K_2O kg/ha). The experiment constituted of 12 treatment combinations were laid out in RBD design with three replications. The twelve treatments *viz.*, T_1 @ Zn (1 g/l), T_2 @ Fe (1 g/l), T_3 @ Zn (1 g/l) + Fe (1 g/l), T_4 @ GA_3 (100 mg/l), T_5 @ Si (0.1%), T_6 @ Zn (1 g/l) + GA_3 (100 mg/l), T_7 @ Fe (1 g/l) + GA_3 (100 mg/l), T_8 @ Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l), T_9 @ Zn (1 g/l) + Si (0.1%), T_{10} @ Fe (1 g/l) + Si (0.1%), T_{11} @ Zn (1 g/l) + Fe (1 g/l) + Si (0.1%) and T_{12} @ Control were prepared and sprayed on the foliage of plants at 30 & 60 DATP with the help of hand sprayer.

Grading of bulb (A, B & C): The grading of bulbs was done on weight basis and classified in following categories.

a. **Grade bulbs:** The harvested bulbs having equatorial diameter 60 mm and above were selected from each treatment and these were considered as 'A' grade bulbs.
b. **Grade bulbs:** The bulbs having equatorial diameter 50 to 60 mm were selected from each treatment and these were considered as 'B' grade bulb.
c. **Grade bulbs:** The bulbs having equatorial diameter 35 to 50 mm recorded as 'C' grade bulbs.

Marketable yield: The total weight of all the A, B and C grade bulbs from each treatment was recorded as marketable yield.

Biochemical components

Moisture: Moisture content of onion bulb estimated according to procedure developed by A.O.A.C. (2000) [2]. A weighted accurate sample about 5 g of the sample and placed it in to the moisture dish which is previously dried in the oven and weighted. Placed the dish in to the oven and maintained at 105 °C for 4 hours. After that cooled it in a desicator and weighted.

Total soluble solids: Randomly five selected onion bulbs were cut into pieces from each treatment and five reading were recorded from extracts for the use of an Erma pocket hand refractometer to estimate total soluble solids.

Reducing sugars: As a method, Somogyi-Nelson (1952) [23] recommended reducing sugars. One gram of sample extracted in 10 ml 80% methanol. The supernatant was gathered and dried on a water bath, 10 ml of water was added to dissolve the sugars. Pipette 0.1 or 0.2 ml aliquots of the methanol-free extract into various test tubes. A series of test tubes were filled with 0.2, 0.4, 0.6, 0.8, and 1 ml of the working standard solution. Alkaline copper tartrate reagent was then added in a volume of 1 ml to each test tube. For 10 minutes, all tubes were kept in boiling water. After cooling, 1 ml of the arseno-molybdic acid reagent was added to each tube. Water was used to create a volume of 10 ml. After 10 minutes, check the blue color's absorbance at 540 nm.

Non reducing sugar: Non reducing sugars were calculated by subtracting the reducing sugar from the total sugar content.

Total soluble sugars: The Phenol-sulphuric Acid Method, as described by Dubois et al. (1956) [9], was modified to determine total soluble sugars. A soluble sugar was extracted from 1.0 g of sample in 10 ml 80% methanol. 1 ml of the extract was dried by evaporation and then dissolved in 10 ml of hot distilled water. A 0.5 ml aliquot was made into a volume of 3 ml with distilled water, then 0.5 ml of distilled phenol was added and thoroughly mixed. At the side of the tube, 5.0 ml of concentrated sulfuric acid was carefully added to the mixture. The tubes were kept at room temperature for 30 minutes after thorough mixing to allow color development. Pipetting the working standard glucose solution (0-100 g) into a number of tubes in the same manner with volumes of 0.5, 1.0, 1.5, 2.0, and 2.55 ml. 490 nm was used to measure the absorbance.

Acidity: Ranganna (1979) [20] method, which was used to calculate titrable acidity. To find the acidity (percent), 10 g of the homogenized sample were used in a 100 ml volumetric flask with distilled water to make up the volume. The suspension was filtered through Whatman No. 1 filter paper. 10 ml of the filtrate were pipetted, collected, and titrated against 0.1 N NaOH. Phenolphthalein was used as an indicator. The change from colorless to pink marks the end point. Reading from a burette was noticed.

Ascorbic acid: The Ranganna (1979) [20] titrimetric method was used to extract ascorbic acid from onion bulbs. 10 g of sample was transferred to a 100 ml volumetric flask and volume made up with 4% oxalic acid solution. Then the suspension was filtered through Whatman No.1 filter paper after 30 minutes. Before actual titration 2, 6 – Dichlorophenol indophenol dye solution was standardized by titrating against standard ascorbic acid solution and the dye factor was calculated. Through the use of a burette, five milliliters of the aliquat were extracted from the filtrate against standardized dye solution. Titration was carried out until the light pink color remained for 15 seconds.

Total phenols: The method described by Bray and Thorpe (1954) [8] with some modifications was used to estimate the total phenols from onion bulbs. Using a mortar and pestle, one gram of the sample was homogenized in 10 ml of 80% methanol. Distilled water was used to convert a volume aliquot of 0.5 ml into a final volume of 1.0 ml. Add 0.5 ml of Folin-Ciocalteu reagent to this, wait three minutes, then add 2 ml of 20% Na_2CO_3. Cool the tubes after one minute in a boiling water bath, and then add 10 ml of distilled water to make the required volume. The absorbance value was established at 650 nm.

Pyruvic acid: Pyruvic acid contents from onion bulb was extracted and estimated by the Randle and Bussard (1993) [19]. A weighted 6 g of sample crushed and added in to 15 ml of phosphate buffer, after that centrifuged it at 25000 rpm for 15 min. thereafter use supernant as sample extract. Took sample extract and made up the final volume of 2 ml with phosphate buffer. There after added the DNPH (Dinitrophenyl hydrazine) solution in each tube. After that incubate it with

37 °C for 20-30 min. added 5 ml of NaOH solution to each tube, mix well and incubate 10 min. at room temperature. Final reading was measured at 610 nm wavelength from spectrophotometer.

Total flavonoids: Jurd and Geissmao (1956) [12] extracted and estimated the onion bulb's total flavonoid content. 0.1N HCl and 10 ml of 60% methanol were used to extract one gram of the sample. The supernatant solution (0.6 ml) was separately combined with 0.6 ml of 2% aluminum chloride. The mixture was then left to sit at room temperature for 60 minutes. Using a spectrophotometer and a blank sample, the reaction mixtures' absorbance was measured at 420 nm.

Mineral components: Onion bulb samples were taken, prepared according to protocol, and their nutritional composition was examined. Fresh tissues were cleaned in turn with distilled water, detergent solution, and diluted HCl. The sample was dried in an oven at 70 ºC after the excess moisture was removed and placed in butter paper bags.

The micro Kjeldahl method, as described by Kanwar and Chopra (1976) [13], was used to determine the total nitrogen in bulb sample. The samples of bulbs were broken down in a di-acid 9:4 mixture of HNO_3 and $HClO_4$ to analyze the nutrients other than nitrogen. To prevent explosions, to measure P, K, Ca, Mg, S, Fe, Mn, Zn, and Cu, aliquots of this solution were used after samples were predigested with 25 ml HNO_3 for every gram of sample.

The phosphorus measured using the Jackson (1974) [11]-described Vanadomolybdo Phosphoric Yellow Colour method. By reacting with vanadomolybdate to create a yellow color complex in an HNO_3 medium, phosphorus content in the extracts was calculated. potassium as determined by the Flame Photometer according to Jackson (1974) [11]. The extract was immediately atomized into the flame photometer after being diluted to the right concentration for K estimation.

Sulphur content determined by the method developed by Williams and Steinbergs (1959) [26]. The barium sulphate turbidimetry technique was used to determine the digest's sulphate content by observing the solution's absorbance or transmittance while using a blue filter.

Calcium & Magnesium in plant samples were determined by directly feeding the aliquot of the extract to the atomic absorption spectro photometer after adjusting the instrument with suitable standards (A.O.A.C., 1984) [1]. Jackson (1967) [10] reported using an atomic absorption spectrophotometer to determine the amounts of copper, zinc, iron, and manganese in di-acid extract.

Statistical analysis: The data were examined using the analysis of variance technique developed by Panse and Sukhatme in 1995. The "F" value was used to test significance at a 5 percent level of probability. For the significant effects, critical differences were determined.

Results and Discussion

Effect on grading of bulb and yield: The grading of bulbs is usually based on bulb size and on the basis of these three different grades is identified such as A, B, and C grade. Amongst these view point of market quality percentage of "A" grade bulbs is important. The treatment Zn (1 g/l) + GA_3 (100 mg/l) (T_6) had caused highest production of "A" grade bulbs in onion. The information in Table 1 showed that application of Zn (1 g/l) + GA_3 (100 mg/l) in treatment T_6 reported significantly higher marketable yield of bulb (45.62 t/ha).

Effect on biochemical components

Moisture: The results presented in Table 2 indicated that significantly lower moisture of 82.42% recorded with treatment T_3 of Zn (1 g/l) + Fe (1 g/l). It remained statistically at par with treatment T_4, T_6 and T_8.

Total soluble solids: The data implied that higher total soluble solids (13.57 ºBrix) was recorded under the treatment T_6 of Zn (1 g/l) + GA_3 (100 mg/l) followed by treatment T_3, T_4 and T_8.

Reducing sugars: The result indicated that treatment T_8 of Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l) had higher reducing sugars (2.16%). It remained statistically at par with treatment T_4 and T_6.

Non-reducing sugar: Treatment T_4 of GA_3 (100 mg/l) revealed significantly higher non-reducing sugar (3.30%) and it was comparable with treatments T_1, T_3, T_6, T_7 and T_8.

Total soluble sugars: The data in Table 2 indicated that Treatment T_6 of Zn (1 g/l) + GA_3 (100 mg/l) had higher total soluble sugars (5.39%). The next best treatments were T_1, T_3, T_4 and T_8.

Acidity: Application of Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l) in treatment T_8 showed significantly higher acidity (0.775%) followed by treatment T_1, T_2, T_3, T_4 and T_6.

Ascorbic acid: The results in Table 3 showed that treatment T_6 of Zn (1 g/l) + GA_3 (100 mg/l) revealed significantly higher ascorbic acid of onion (14.22 mg/100 g). It remained statistically at par with treatment T_1, T_3, T_4 and T_8.

Total phenols: The treatment T_6 of Zn (1 g/l) + GA_3 (100 mg/l) recorded higher total phenols of onion (106.31 mg/100 g), whereas it remained statistically at par with treatment T_1, T_3, T_4, T_7, T_8 and T_{11}.

Pyruvic acid: The information in Table 3 showed that treatment T_8 of Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l) had higher pyruvic acid (44.05 mg/100 g), whereas it remained statistically at par with treatment T_1, T_3 and T_6.

Total flavonoids: Significantly higher total flavonoids of 89.75 mg/100 g recorded with treatment T_6 of Zn (1 g/l) + GA_3 (100 mg/l). It remained statistically at par with treatment T_1, T_3, T_4 and T_8.

Effect on mineral components

Nitrogen: From the Table 4, the data showed that significantly higher nitrogen content (5.86%) was recorded under the treatment T_8 of Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l) followed by treatment T_6.

Phosphorus

Significantly higher phosphorus content (0.89%) was observed in treatment T_6 of Zn (1 g/l) + GA_3 (100 mg/l). It was closely followed by treatments T_8 and T_3.

Potassium: The data showed that higher potassium content in onion bulb (0.60%) observed under treatment T_4 of GA_3 (100 mg/l). It remained at par with all the treatments except T_5, T_9, T_{10}, T_{11} and T_{12}.

Sulphur: Application of Zn (1 g/l) + GA_3 (100 mg/l) in treatment T_6 recorded significantly higher sulphur content in onion bulb. It remained statistically at par with the treatments T_8, T_4, T_3 and T_1.

Magnesium: The information in Table 4 showed that the Zn (1 g/l) + GA_3 (100 mg/l) treatment (T_6) resulted in significantly higher magnesium content (1084.5 ppm). It was followed by treatment T_3.

Calcium: The result indicated that significantly higher calcium content in onion bulb of 939.1 ppm recorded with treatment T_8 of Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l). Significantly at par relation was recorded with treatments T_4 and T_6.

Iron

Application of GA_3 (100 mg/l) in treatment T_4 showed higher iron content in onion bulb (45.05 ppm) followed by treatments T_3, T_6 and T_8.

Zinc: The data implied that application of Zn (1 g/l) + Fe (1 g/l) in treatment T_3 recorded significantly higher zinc content in onion bulb (9.99 ppm). The next best treatment was T_3 of Zn (1 g/l) + GA_3 (100 mg/l).

Manganese

The information in Table 4 showed that treatment T_6 of Zn (1 g/l) + GA_3 (100 mg/l) observed significantly higher manganese content in onion bulb, whereas it remained statistically at par with treatments T_3 and T_8.

Copper

Significantly higher copper content (7.89 ppm) was recorded under the treatment T_6 of Zn (1 g/l) + GA_3 (100 mg/l). It was followed by treatments T_3 and T_8.

Table 1: Effect of micronutrients and plant growth regulator on grading of bulb and marketable yield of onion (*Allium cepa* L.) (Pooled value of two years)

Treatments		Grading of bulbs			Marketable yield (t/ha)
		'A' grade bulb (t/ha)	'B' grade bulb (t/ha)	'C' grade bulb (t/ha)	
T_1: Zn (1 g/l)		21.15	12.05	7.17	40.38
T_2: Fe (1 g/l)		20.69	11.86	7.34	39.89
T_3: Zn (1 g/l) + Fe (1 g/l)		24.31	14.27	6.37	44.95
T_4: GA_3 (100 mg/l)		21.79	12.36	7.44	41.59
T_5: Si (0.1%)		18.73	10.67	7.95	37.36
T_6: Zn (1 g/l) + GA_3 (100 mg/l)		25.06	14.71	5.85	45.62
T_7: Fe (1 g/l) + GA_3 (100 mg/l)		22.31	12.76	7.32	42.39
T_8: Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l)		23.42	13.48	6.93	43.84
T_9: Zn (1 g/l) + Si (0.1%)		19.83	11.35	7.34	38.52
T_{10}: Fe (1 g/l) + Si (0.1%)		18.70	10.68	7.95	37.32
T_{11}: Zn (1 g/l) + Fe (1 g/l) + Si (0.1%)		20.33	11.60	7.18	39.11
T_{12}: Control		15.89	8.83	10.95	35.67
S.Em. ±	Y	0.32	0.19	0.17	0.62
	T	0.78	0.47	0.41	1.53
	Y × T	1.11	0.67	0.58	2.16
C. D. at 5%	Y	0.92	0.55	NS	1.78
	T	2.24	1.35	1.18	4.37
	Y × T	NS	NS	NS	NS
C.V. %		9.17	9.69	13.60	9.26

Table 2: Effect of micronutrients and plant growth regulator on biochemical components (moisture, TSS, reducing sugars, non-reducing sugars, total soluble sugars) of onion (*Allium cepa* L.) (Pooled value of two years)

Treatments		Moisture (%)	TSS (ºBrix)	Reducing sugars (%)	Non-reducing sugar (%)	Total soluble sugars (%)
T_1: Zn (1 g/l)		86.37	12.24	1.99	3.17	5.16
T_2: Fe (1 g/l)		86.92	11.70	1.92	2.81	4.73
T_3: Zn (1 g/l) + Fe (1 g/l)		82.42	13.11	1.98	3.17	5.15
T_4: GA_3 (100 mg/l)		84.74	12.54	2.03	3.30	5.34
T_5: Si (0.1%)		88.48	11.50	1.90	2.80	4.70
T_6: Zn (1 g/l) + GA_3 (100 mg/l)		82.46	13.57	2.10	3.29	5.39
T_7: Fe (1 g/l) + GA_3 (100 mg/l)		87.28	12.07	1.91	2.93	4.84
T_8: Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l)		84.77	13.11	2.16	3.13	5.30
T_9: Zn (1 g/l) + Si (0.1%)		86.43	11.74	1.97	2.61	4.58
T_{10}: Fe (1 g/l) + Si (0.1%)		88.32	11.92	1.87	2.70	4.58
T_{11}: Zn (1 g/l) + Fe (1 g/l) + Si (0.1%)		86.29	12.24	1.95	2.78	4.73
T_{12}: Control		91.51	10.73	1.64	2.47	4.11
S.Em. ±	Y	0.49	0.15	0.02	0.05	0.05
	T	1.21	0.37	0.05	0.13	0.13
	Y × T	1.72	0.53	0.07	0.19	0.19
C. D. at	Y	NS	NS	NS	NS	NS

5%	T	3.47	1.08	0.15	0.38	0.39
	Y × T	NS	NS	NS	NS	NS
C.V. %		3.46	7.61	6.90	11.28	6.86

Table 3: Effect of micronutrients and plant growth regulator on biochemical components (acidity, ascorbic acid, total phenols, pyruvic acid, total flavonoids) of onion (*Allium cepa* L.) (Pooled value of two years)

Treatments		Acidity (%)	Ascorbic acid (mg/100 g)	Total phenols (mg/100 g)	Pyruvic acid (mg/100 g)	Total flavonoids (mg/100 g)
T_1: Zn (1 g/l)		0.726	13.25	99.50	40.63	85.35
T_2: Fe (1 g/l)		0.720	12.49	91.46	39.99	81.71
T_3: Zn (1 g/l) + Fe (1 g/l)		0.757	13.94	104.84	42.96	88.87
T_4: GA_3 (100 mg/l)		0.745	14.20	105.06	39.23	86.22
T_5: Si (0.1%)		0.671	12.60	96.73	38.40	80.81
T_6: Zn (1 g/l) + GA_3 (100 mg/l)		0.757	14.22	106.31	42.88	89.75
T_7: Fe (1 g/l) + GA_3 (100 mg/l)		0.688	13.10	103.72	36.99	82.15
T_8: Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l)		0.775	13.76	106.03	44.05	88.49
T_9: Zn (1 g/l) + Si (0.1%)		0.703	12.98	92.83	39.75	79.88
T_{10}: Fe (1 g/l) + Si (0.1%)		0.694	12.55	95.67	40.02	82.62
T_{11}: Zn (1 g/l) + Fe (1 g/l) + Si (0.1%)		0.690	12.90	101.44	37.70	80.02
T_{12}: Control		0.613	12.20	88.89	35.66	75.08
S.Em. ±	Y	0.009	0.15	1.23	0.51	0.93
	T	0.023	0.37	3.02	1.25	2.28
	Y × T	0.032	0.53	4.27	1.77	3.23
C. D. at 5%	Y	0.030	NS	3.52	1.46	NS
	T	0.064	1.08	8.62	3.56	6.52
	Y × T	NS	NS	NS	NS	NS
C.V. %		7.76	7.04	7.46	7.69	6.72

Table 4: Effect of micronutrients and plant growth regulator on mineral components of onion (*Allium cepa* L.) (Pooled value of two years)

Treatments		N (%)	P (%)	K (%)	S (%)	Ca (mg/l)	Mg (mg/l)	Fe (mg/l)	Zn (mg/l)	Mn (mg/l)	Cu (mg/l)
T_1: Zn (1 g/l)		4.42	0.74	0.55	0.25	736.1	949.5	33.98	7.66	4.40	5.04
T_2: Fe (1 g/l)		2.61	0.60	0.55	0.23	688.0	883.1	34.93	5.10	4.33	3.18
T_3: Zn (1 g/l) + Fe (1 g/l)		5.22	0.80	0.57	0.25	816.0	1016.1	41.05	9.99	5.03	5.84
T_4: GA_3 (100 mg/l)		4.50	0.77	0.60	0.27	918.3	917.1	45.05	8.18	4.43	5.09
T_5: Si (0.1%)		2.13	0.61	0.49	0.21	676.0	731.9	30.00	6.50	3.62	4.08
T_6: Zn (1 g/l) + GA_3 (100 mg/l)		5.68	0.89	0.58	0.28	877.2	1084.5	39.16	9.73	5.12	7.89
T_7: Fe (1 g/l) + GA_3 (100 mg/l)		3.95	0.68	0.56	0.23	857.3	893.6	31.35	8.81	3.49	4.99
T_8: Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l)		5.86	0.81	0.59	0.27	939.1	951.9	37.60	8.79	4.92	5.73
T_9: Zn (1 g/l) + Si (0.1%)		2.53	0.71	0.51	0.24	734.6	852.7	20.90	6.99	3.74	4.36
T_{10}: Fe (1 g/l) + Si (0.1%)		3.76	0.64	0.54	0.20	577.8	817.1	27.32	6.73	4.06	4.52
T_{11}: Zn (1 g/l) + Fe (1 g/l) + Si (0.1%)		1.66	0.71	0.53	0.22	730.0	871.4	22.43	7.45	3.68	4.99
T_{12}: Control		1.21	0.49	0.46	0.20	485.8	623.7	16.05	4.18	2.66	2.64
S.Em. ±	Y	0.07	0.008	0.006	0.004	10.13	10.17	0.44	0.15	0.05	0.09
	T	0.19	0.021	0.01	0.010	24.83	24.91	1.08	0.36	0.13	0.23
	Y × T	0.27	0.029	0.02	0.014	35.12	35.23	1.54	0.52	0.19	0.33
C. D. at 5%	Y	NS	NS	NS	NS	NS	NS	1.27	NS	NS	NS
	T	0.54	0.059	0.04	0.028	70.78	71.00	3.10	1.04	0.38	0.67
	Y × T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %		13.00	7.19	6.68	9.99	8.08	6.91	8.43	12.00	8.09	11.86

Effect on grading of bulb and yield: Weight of "A" and "B" grades bulbs the foliar application had a significant impact of micronutrients and plant growth regulator. Increases in onion bulb weight, volume, and diameter seen in the current study may be the cause of the rise in "A" and "B" grades. In case of 'C' grade bulbs also showed significant and recorded lower values over control. This might be increase due to the higher accumulation of food reserves, cell multiplication and cell elongation by micronutrients and plant growth regulator. The increase in marketable yield might be the result of increased photosynthetic rate, which typically results in increased yield, as well as increased chlorophyll content. The main factor contributing to the increased yield may be the above treatments' manipulation of the source–sink relationship between the leaf and the bulb.

The present study are in close conformity with the finding of Patel *et al.* (2010) [17]. Biswas *et al.* (2020) [7] also reported that treatment having RDF+ Foliar application of Micronutrient Mixture i.e. iron (2.5%), boron (0.5%), zinc (3%), copper (1%) and manganese (1%) at 30 & 45 DAP recorded highest 'A' & 'B' grade bulbs, bulb yield of onion and lower values of 'C' grade bulbs.

Effect on biochemical components: Moisture content of bulb is the important character for shelf life of onion. Lower moisture content is required for extension of shelf life and prevention of spoilage by organisms, enzymes and vinegar flies. Micronutrients and plant growth regulator treatments help to enhance TSS content in onion bulb. The higher carbohydrate production during photosynthesis may be the cause of the increased TSS of bulbs and also due to some improved physiological and biochemical activities in plant system under the influence of micronutrients and growth regulator treatment.

Applications of micronutrients and growth regulator treatments increased the different biochemical parameters like reducing sugar, non-reducing sugar, total soluble sugar and acidity content of onion bulb. Plant growth regulators and micronutrients may boost the activity of amylases, an enzyme that hydrolyzes complex polysaccharides into simple sugars. Translocation of metabolites from other plant regions to developing bulbs is sped up by plant growth regulators.

Ascorbic acid is antioxidant and it plays a protective role in plants. Ascorbic acid influences many enzymes activities. Ascorbic acid levels in bulbs may have increased as a result of the oxidase enzyme's accelerated activity brought on by the use of micronutrients and plant growth regulators. During storage, the onion bulb's phenolic content is crucial because it protects it from disease. Due to phenolic compounds' increased resistance to the effects of digestive enzymes on the cell wall, they may be indirectly to blame for the resistance to pathogenic fungi.

The increasing level of pyruvic acid and total flavonoids in onion bulb might be due to the application of micronutrients and plant growth regulator. The perception of pungency and the amount of pyruvate produced by enzymes in onions are widely acknowledged to be highly correlated. The analysis of this parameter was crucial for determining onion aroma characteristics and estimating their potential flavor. Flavonoids are mostly 15-C phenolic compound and usually occurring as glycosides. They are soluble in water and also provide strength to plant against various stresses.

This result is closed agreement with many research workers. The work of Khashti and Rana (2012) [14] clearly indicated the micronutrients like Zn @ 4 mg/l recorded maximum TSS (13.9 ºB) and total soluble sugar (6.1%). The same trend was observed by Ballabh *et al.* (2013) [6] and Manna *et al*. (2013) [15]. Singh *et al.* (2013) [22] had also reported maximum TSS (11.93 ºB), total sugar (5.52%), ascorbic acid (12.85 mg/100 g) and total phenol (187.49 mg/100 g) with the application of gibberellic acid @ 80 ppm. The findings of Trivedi and Dhumal (2017) [25] indicated that Zn and Fe used through foliar spraying alone and combination with amino acid, GA_3 and 2-4-D emerged as the best treatment for TSS and total phenols content in onion. Similar result was reported by Pramanik *et al*. (2018) [18]. Sravani *et al*. (2020) [24] reported that the treatment (GA_3 25 mg l^{-1}) recorded highest ascorbic acid content (10.45 mg 100 g^{-1}), moisture content (83.98%) and total phenols (61.77 mg 100 g^{-1}) in onion.

Effect on mineral components: Following the foliar application of micronutrients and a plant growth regulator, favorable soil, water, and other conditions may have been present, which may have contributed to the improvement in onion bulbs' mineral content that has been seen overall in this investigation. All of these favorable circumstances may have stimulated the plant's uptake and availability of different mineral nutrients. The mineral content of onion bulbs improved as a result. Throughout the onion plant's entire life cycle, the application of micronutrients and a plant growth regulator may have promoted strong, healthy root growth. The transfer of these mineral nutrients from the leaves into the bulbs during bulb curing may be very effective during leaf senescence and neck fall. Thus, the foliar application of micronutrients and plant growth regulators promotes the movement of mineral components into bulbs from below.

The rise in the amount of protein and amino acids in bulbs may result directly or indirectly from the improvement in nitrogen content. An improvement in P could be helping to significantly increase total carbohydrates, sugars, etc. Higher potassium levels in bulbs could a significant impact on how disease-resistant they are while being stored. Furthermore, it is asserted that K encourages the production and buildup of phenol. These phenols function as a deterrent because they have antibacterial and antifungal properties. Sulfur plays a crucial part in controlling bulb pungency, which is linked to bulb quality. Calcium is an important component of cell wall and maintains structure of cell membrane. Magnesium plays a significant role in chlorophyll synthesis, as it occupies central position in chlorophyll. Similar to there are numerous enzymatic reactions that involve the other mineral nutrients, iron, copper, manganese, and zinc. that regulate a number of biosynthetic pathways. Therefore, the overall increase in macro and micronutrients bulb provided a wide range of advantages for both the quality and quantity of dietary supplements and bulb yield.

The present investigation is in conformity with the results of Abu – Grab *et al.* (2000) [4]. Attia (2001) [5] reported that micronutrients (Fe, Mn and Zn) significantly enhanced the yield, dry matter percentage, and total N, P, K, Fe, Mn and Zn contents of onion bulbs. Similar result was reported by Singh *et al.* (2002) [21], Abd El-Samad *et al.* (2011) [3] and Trivedi and Dhumal (2017) [25]. They confirmed that combination of micronutrients and plant growth regulator was a successful way to increase the mineral content of bulbs.

Conclusion

Based on the results, it is concluded that treatment T_6 of Zn (1 g/l) + GA_3 (100 mg/l) at 30 and 60 days after transplanting had maximum A & B grade bulb, TSS, total soluble sugars, total phenols, ascorbic acid, total flavonoids, phosphorus, sulphur and magnesium content of onion bulb followed by treatment T_8 of Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l).

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