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Study on the impact of foliar application of growth regulators and micronutrients on morpho-physiological and yield parameters of onion (*Allium cepa* L.) cv. GAWO-2

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Abstract
An experiment took place at the experimental farm of the Main Vegetable Research Centre, Anand Agricultural University, Anand. This occurred during the winter crop season of the years 2019-20 and 2020-21 to investigate the impact of micronutrients and a plant growth regulator on the growth of onions. The twelve different treatments were examined using a Randomized Block Design with three replications. The results of the experiment indicated that applying micronutrients and a plant growth regulator through the leaves led to enhancements in both physiological and yield characteristics. Among the application of micronutrients and growth regulators, the greatest value of physiological parameter like plant height, number of leaves, leaf length, total dry matter, AGR, CGR, RGR and total chlorophyll were recorded from foliar application of Zn (1 g/l) + GA_3 (100 mg/l) followed by Zn (1 g/l) + Fe (1 g/l). The foliar application of Zn and GA_3 also recorded the highest polar diameter of bulb, average weight of bulb and marketable yield of onion.

Keywords: Onion, CGR, GA_3, Zn, marketable yield

Introduction
The onion (*Allium cepa* L.) a vital commercial vegetable, is a member of the Alliaceae family and is cultivated throughout the nation. It thrives in tropical, subtropical, and temperate regions around the globe. Its origins trace back to the territory encompassing North West India, Afghanistan, Tasik, Uzbek, and the vicinity surrounding the Mediterranean Sea. In global onion production, India holds the second position after China, and it ranks third in onion exports, following the Netherlands and Spain. Maharashtra takes the lead as the largest onion-producing state in India, followed by Karnataka and Gujarat. On a significant scale, the crop is cultivated in states such as Orissa, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Rajasthan, and Bihar. The total production of onion in India is 26.73 million tonnes from an area of 1.43 million hectares while Gujarat occupies an area of about 48.58 thousand hectares with production of 1416.31 thousand metric tonnes (Anon., 2020) [2].

The consistent need for onions domestically and for export purposes has underscored the necessity of ensuring year-round onion supply, whether from newly harvested sources or existing stockpiles. A review of area and production of major vegetables crops shows that onion ranks second in area under vegetables and third in production in the world. The opportunities for vegetable growing have greatly widen because the country has a highly diversified agro climatic conditions, favorable for the cultivation of wide range of vegetables, which are in great demand in domestic and export market. The gap between the present productivity a technically proven potential is very wide which can be minimized by using recent technology to boost the yield of vegetables.

The application of micronutrients to soil deficient in them has demonstrated a striking increase in crop yield. From cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity, nitrogen fixation, and other aspects of plant metabolism, micronutrients play a significant role. Numerous enzymes require co-factors, which are provided by micronutrients. They are also crucial for increasing quality and yield, and many crops' better plant growth and yield depend on them. The growth, yield, and quality of onions were improved by foliar applications of micronutrients. Plant growth regulators (PGRs) are well known for increasing a plant's physiological efficiency, including their capacity for photosynthetic activity. They also play a significant part in achieving higher crop yields.

Cell division, cell elongation, auxin metabolism alteration, and cell wall plasticity are all induced by different plant growth regulators. Additionally, they have a history of improving the source-sink relationship and promoting the translocation of photo assimilates, both of which increase productivity.

There is a scarcity of data on the effects of plant growth regulators and micronutrients on morphological, physiological, and yield parameters. To increase onion productivity, it is crucial to research how micronutrients and plant growth regulators affect its morpho-physiological and yield components. In light of this, the current study sought to identify the most effective micronutrients and growth regulators for raising onion yield potential.

Materials and Methods

At the experimental farm of the Main Vegetable Research Centre, Anand Agricultural University, Anand, a field experiment was carried out during the rabi seasons of the years 2019–20 and 2020–21. The treatments of micronutrients and growth regulators were applied as foliar applications twice during the period of crop growth, namely, 30 and 60 days after transplanting. The experiments were set up in an RBD design with 12 treatment combinations of growth regulator and micronutrients replicated thrice. 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 taken in present investigation.

The seedlings of 45 days old were transplanted in 3.0 m x 2.0 m sized plots at 15 ×10 cm^2 spacing. The recommended dose of fertilizers of 100-50-00 kg NPK ha^{-1} was followed in all the treatments. Each plot has its own irrigation channels that were built to ensure proper irrigation. Regular intervals of irrigation work and intercultural activities were performed as needed. The soil of the experiment plot was loamy sand. The soil has available phosphorus (35.40 kg/ha), available nitrogen (200.4 kg/ha), and available potassium (256.39 kg/ha). In this experiment, a high yielding white onion variety called GAWO-2 was used. It had a higher bulb, a lower index of the purple blotch disease, and a lower incidence of thrips.

At 45, 75, 105 DATP and at harvest, morphological characteristics such as plant height, the number of leaves per plant, and leaf length were recorded from the selected plants in each treatment from all replications.

Physiological parameters like total dry matter, Absolute growth rate (AGR), Crop growth rate (CGR), Relative growth rate (RGR) and Total chlorophyll were recorded. Total dry matter was recorded from each treatment at 45, 75, 105 DATP & at harvest. Absolute growth rate (AGR) and Crop growth rate (CGR) were calculated by using the formula given by Watson (1952) [20] at 45-75, 75-105 & 105-at harvest. Relative growth rate (RGR) was calculated by using the formula given by Blackman (1919) [6]. Total chlorophyll content as well as chlorophylls 'a' and 'b' were estimated using the technique outlined by Hiscox and Israelstam (1979) [9]. From each treatment, yield and characteristics that influence yield, such as polar and equatorial bulb diameter, neck thickness, average bulb weight, and marketable yield, were recorded.

According to Panse and Sukhatme's (1995) [13] method of analysis of variance, the data were tabulated and statistically analyzed to determine whether the treatment means were superior. The "F" value was used to test significance at the 5% level of probability. For the significant effects, critical differences were identified.

Results and Discussion

Effect on morphological parameters

Plant height (cm): Plant height of onion increased progressively with advance in age of crop up to harvest. The data of plant height presented in Table 1 clearly indicated a significant difference among the treatments with response to foliar application micronutrients and plant growth regulator treatments. Significantly higher plant height (34.14, 44.63, 50.46 and 51.92 cm) at 45, 75, 105 DATP and at harvest, respectively was recorded under the application of Zn (1 g/l) + GA_3 (100 mg/l) in treatment T_6 followed by the treatments T_1, T_3, T_4 and T_8.

Number of leaves/plant: The highest number of leaves per plant (6.43) was obtained under treatment T_6 of Zn (1 g/l) + GA_3 (100 mg/l) at 45 DATP, while the highest number of leaves per plant at 75 and 105 DATP was obtained under treatment T_4 of GA_3 (100 mg/l). At harvest, the application of GA_3 (100 mg/l) in treatment T_4 and Zn (1 g/l) + GA_3 (100 mg/l) in treatment T_6 respectively, resulted in the highest number of leaves per plant of 9.90. Regarding the quantity of leaves per plant, the T_8 treatment had also demonstrated promising results.

Leaf length: The data in the table showed that the application of GA_3 (100 mg/l) was followed by treatment T_8 of Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l), which resulted in significantly longer leaves (29.04, 33.91, 37.07, and 38.14 cm) at 45, 75, 105 DATP and at harvest, respectively.

The increase in plant height, no. of leaves/plant and leaf length may be due to cell division, meristematic activity of plant tissue and expansion of cell as affected by foliar application micronutrients and growth regulator. All these positive results may be the outcome of growth regulator like GA_3, as their role in cell division, elongation and growth has been well documented by several workers in different cereals and vegetables. The effect of gibberellins was boosted by the additional positive effect of micronutrients like Zn.

Tyagi and Yadav (2007) [19] found a similar result in onions and came to the conclusion that GA_3 @ 60 ppm was the best for onion leaf length and plant number of leaves. Ballabh *et al*. (2013) [4] found in a study that was similar to theirs that foliar feeding of Zn @ 4 mg/l significantly improved vegetative growth parameters in onion when compared to other micronutrients. According to Manna *et al.* (2014) [14], Babaleshwar *et al.* (2017) [3], Devi *et al.* (2018) [7], and Sarkar *et al.* (2018) [16], the same trend has been observed. Rashid and Islam's research from 2019 showed that B+Zn+Cu application at 0.2+0.5+0.2 g/plot led to the highest plant height and number of leaves in onion.

Effect on physiological parameters

Total dry matter: From the Table 2, the data showed that highly significant difference was observed in total dry matter in onion. Among different treatments of micronutrients and plant growth regulators, the higher total dry matter was obtained under treatment T_4 of GA_3 (100 mg/l) at 45 DATP, while at 75 DATP and at harvest higher total dry matter production was obtained under treatment T_6 of Zn (1 g/l) + GA_3 (100 mg/l). At 105 DATP, higher total dry matter production was obtained under treatment T_4 of GA_3 (100 mg/l) and treatment T_6 of Zn (1 g/l) + GA_3 (100 mg/l).

Absolute growth rate: Significantly higher absolute growth rate (0.165 and 0.280 g/days) at 75-105 DATP and 105 DATP-at harvest, respectively was recorded under the treatment T_4 of GA_3 (100 mg/l) and treatment T_6 of Zn (1 g/l) + GA_3 (100 mg/l).

Crop growth rate: The higher crop growth rate was obtained under treatment T_4 of GA_3 (100 mg/l) at 75-105 DATP, while at 105 DATP-at harvest higher crop growth rate was obtained under treatment T_6 of Zn (1 g/l) + GA_3 (100 mg/l).

Relative growth rate: The data presented in table 3 revealed that significantly higher relative growth rate recorded with application of GA_3 (100 mg/l) in treatment T_4 at 75-105 DATP. Significantly higher relative growth rate of onion observed under treatment T_4 @ GA_3 (100 mg/l) and T_6 @ Zn (1 g/l) + GA_3 (100 mg/l) at 105 DATP- at harvest. This treatment was followed by treatments T_1, T_3, and T_8.

Total chlorophyll: Significantly higher total chlorophyll (1.10, 1.26, 1.36 and 1.28 mg/g) at 45, 75, 105 DATP and at harvest, respectively was recorded under the treatment T_8 of Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l) which was closely related to the treatment T_2, T_3 and T_6.

Micronutrients promote the strong steady growth of crops that produces higher yield and increase quality, maximizing the plants genetic potential. In particular, their presence can have great impact on root development, bulb setting and other growth parameters. Zinc is an important constituent of several enzymes and proteins. However, it is crucial to plant development, as it plays a significant part in a wide range of processes. Plant growth regulators encourage phototropism and cell elongation in the plant stem. Gibberellins regulate plant growth, differentiation, and morphogenesis most likely by exerting their control over specific metabolic reactions in the target tissue via receptor molecules. They also cause shoots to elongate so that plants can grow taller and leaves to grow bigger. Ultimately lead to an increase in growth parameters. Micronutrients and growth regulators are critical for improving quality, controlling enzymatic activity, and increasing chlorophyll content. Applications of Fe and Zn, either as a soil or foliar application, increased the yield, biochemical constituents, and morpho-physiological characteristics. This could be as a result of increased photosynthesis brought on by higher levels of photo harvesting pigment in leaves.

The results obtained in present study are in close conformity with the finding of Abu – Grab *et al.* (2000) [1]. They investigated the effect of gibberellic acid (GA_3) growth of onions and showed that GA_3 result highest value of scape length, dry weight per plant and induce increase in the chlorophyll a and chlorophyll a+b of onion. Similar results were reported by Ouzounidou *et al.* (2011) [12] and Sarkar *et al.* (2018) [16]. The findings of Dwivedi *et al.* (2019) [8] regarding the application of GA_3 in onion through foliar spraying clearly reported that growth regulators were effective to enhance dry weight of plant. Rashid and Islam (2019) [15] investigate the effects of micronutrients on bulb growth of onion cultivars and they showed that the application of B+Zn+Cu @ 0.2+0.5+0.2 g/plot produced the highest per cent dry matter content of bulbs. Similar result was observed by Sravani *et al*. (2020) [17] reported that GA_3 (25 mg l^{-1}) recorded highest chlorophyll content of leaves at 45 DATP (1.06 mg/100 g), 60 DATP (2.64 mg/100 g), 90 DATP (2.32 mg/100 g).

Effect on yield and yield components

Polar diameter of bulb: Application of Zn (1 g/l) + GA_3 (100 mg/l) in treatment T_6 reported significantly higher polar diameter of bulb (5.54 cm). It remained statistically at par with the treatments T_3, T_7 and T_8, whereas the lower polar diameter of bulb of onion recorded under treatment T_{12} (Control).

Equatorial diameter of bulb: The data presented in table revealed that significantly higher equatorial diameter of bulb of 6.27 cm recorded with treatment T_8 of Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l). The treatments T_3, T_4, T_6, T_7, T_9 and T_{11} recorded significantly at par with respect to equatorial diameter of bulb of onion.

Average weight of bulb: The data presented in Table 4 showed that application of Zn (1 g/l) + GA_3 (100 mg/l) in treatment T_6 reported significantly higher average weight of bulb (71.67 g). In contrast to it, lowest average weight of bulb of onion was observed under treatment T_{12} (Control).

Marketable yield: 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). It remained statistically at par with the treatments T_3 @ Zn (1 g/l) + Fe (1 g/l), T_4 @ GA_3 (100 mg/l), T_7 @ Fe (1 g/l) + GA_3 (100 mg/l) and T_8 @ Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l).

The effect of micronutrients and plant growth regulator on diameter of bulb was significantly increased over control. The increase in diameter of bulb due to the higher accumulation of food reserves, cell multiplication and cell elongation by micronutrients and plant growth regulator. The increase in average weight of bulb recorded in present investigation might be due to improved growth and yield attributes as a results of positive influence of micronutrients and growth regulator on the physiology of plant which results in higher photosynthesis and more accumulation of food reserve in bulb finally resulting in to better development of bulbs and improved bulb weight. The marketable yield was significantly increased over control by application of micronutrients and plant growth regulator. The increase in marketable yield might be due to increased of chlorophyll content and thereby photosynthetic rate, which usually cause increase in the yield. Manipulation of source (leaf) and sink (bulb) relationship through the above treatments may be the principal reason for yield improvement.

These results are in accordance with the results obtained by Patel *et al.* (2010) [14]. They observed that application of GA_3 50 mg/l as foliar spray significantly increased volume of bulb, equatorial and polar diameter of bulb and bulb yield of onion. Manna and Maity (2016) [10] reported that application of Zinc @ 0.5 per cent exhibited the best growth in bulb diameter and yield in onion. These findings were in agreement with the work of Trivedi and Dhumal (2017) [18]. Similarly the researchers like, Dwivedi *et al.* (2019) [8] also reported that maximum polar diameter (5.77 cm) and equatorial diameter (5.91 cm) of onion bulb were exhibited in the treatment (GA_3 @ 100 ppm-foliar spray). The work of Biswas *et al.* (2020) revealed that the treatment of RDF+ Foliar application of Micronutrient Mixture i.e. iron (2.5%), boron (0.5%), zinc (3%), copper (1%) and manganese (1%) at 30 & 45 DATP recorded higher polar diameter (58.62 mm), equatorial diameter (46.88 mm), average weight of bulb (61.72 g) and bulb yield (266.80 q ha^{-1}).

Table 1: Effect of micronutrients and plant growth regulator on morphological parameters (plant height, no. of leaves/plant, leaf length) of onion (*Allium cepa* L.) (Pooled value of two years)

Treatments		Plant height (cm)				No. of leaves/plant				Leaf length (cm)			
		45 DATP	75 DATP	105 DATP	At harvest	45 DATP	75 DATP	105 DATP	At harvest	45 DATP	75 DATP	105 DATP	At harvest
T_1: Zn (1 g/l)		31.63	41.42	46.80	48.49	5.70	7.33	8.63	9.17	27.58	32.04	35.03	36.04
T_2: Fe (1 g/l)		29.06	39.49	44.29	45.90	5.33	6.60	8.00	8.70	26.91	31.86	34.60	36.02
T_3: Zn (1 g/l) + Fe (1 g/l)		33.37	43.12	48.95	50.51	5.77	6.97	8.37	9.10	27.57	32.89	36.21	36.93
T_4: GA_3 (100 mg/l)		32.79	43.19	48.35	50.18	6.23	7.80	9.23	9.90	29.04	33.91	37.07	38.14
T_5: Si (0.1%)		28.68	38.58	43.56	45.69	4.90	5.87	7.57	8.00	24.65	29.46	32.12	33.58
T_6: Zn (1 g/l) + GA_3 (100 mg/l)		34.14	44.63	50.46	51.92	6.43	7.53	9.07	9.90	28.59	33.21	36.22	37.35
T_7: Fe (1 g/l) + GA_3 (100 mg/l)		30.51	40.76	46.05	47.41	5.50	6.70	8.10	8.63	26.89	31.87	34.95	36.26
T_8: Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l)		33.78	43.07	48.93	50.26	6.10	7.37	8.87	9.73	28.39	32.91	35.75	37.36
T_9: Zn (1 g/l) + Si (0.1%)		30.85	40.66	45.93	47.68	5.33	6.37	7.87	8.40	24.66	29.81	32.70	33.94
T_{10}: Fe (1 g/l) + Si (0.1%)		29.41	38.99	44.33	46.18	4.60	5.73	7.33	7.83	26.24	31.43	34.31	35.60
T_{11}: Zn (1 g/l) + Fe (1 g/l) + Si (0.1%)		30.57	40.76	46.04	48.16	5.43	6.43	7.87	8.47	25.59	30.16	32.71	34.29
T_{12}: Control		26.51	35.54	40.08	42.20	4.13	5.30	6.90	7.53	22.27	26.38	28.70	30.41
S.Em. ±	Y	0.39	0.47	0.53	0.50	0.06	0.07	0.08	0.08	0.36	0.39	0.41	0.40
	T	0.95	1.15	1.30	1.22	0.14	0.18	0.20	0.19	0.89	0.95	1.01	0.98
	Y × T	1.35	1.63	1.84	1.73	0.19	0.26	0.29	0.27	1.26	1.34	1.43	1.39
C. D. at 5%	Y	1.11	1.34	1.52	1.42	NS	NS	NS	NS	1.03	1.10	1.17	NS
	T	2.72	3.29	3.72	3.48	0.39	0.52	0.58	0.54	2.54	2.70	2.88	2.79
	Y × T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%		7.54	6.91	6.92	6.25	6.18	6.72	6.12	5.30	8.21	7.42	7.23	6.76

Table 2: Effect of micronutrients and plant growth regulator on physiological parameters (TDM, AGR, CGR) of onion (*Allium cepa* L.) (Pooled value of two years)

Treatments		TDM (g/plant)				AGR (g/days)			CGR (g/m^2/days)		
		45 DATP	75 DATP	105 DATP	At harvest	45-75 DATP	75-105 DATP	105 DATP-at harvest	45-75 DATP	75-105 DATP	105 DATP-at harvest
T_1: Zn (1 g/l)		10.62	13.73	18.52	23.84	0.104	0.159	0.266	6.92	10.63	17.74
T_2: Fe (1 g/l)		10.36	13.26	17.83	22.80	0.097	0.152	0.249	6.45	10.15	16.57
T_3: Zn (1 g/l) + Fe (1 g/l)		10.62	13.73	18.52	23.84	0.104	0.159	0.266	6.92	10.63	17.75
T_4: GA_3 (100 mg/l)		10.89	14.10	19.06	24.66	0.107	0.165	0.280	7.13	11.02	18.68
T_5: Si (0.1%)		10.04	12.86	17.24	21.91	0.094	0.146	0.233	6.26	9.73	15.56
T_6: Zn (1 g/l) + GA_3 (100 mg/l)		10.84	14.11	19.06	24.67	0.109	0.165	0.280	7.27	11.01	18.69
T_7: Fe (1 g/l) + GA_3 (100 mg/l)		10.37	13.43	18.07	23.17	0.102	0.155	0.255	6.81	10.32	16.99
T_8: Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l)		10.70	13.85	18.69	24.10	0.105	0.161	0.271	7.00	10.75	18.04
T_9: Zn (1 g/l) + Si (0.1%)		10.53	13.59	18.31	23.53	0.102	0.157	0.261	6.81	10.49	17.40
T_{10}: Fe (1 g/l) + Si (0.1%)		9.87	12.59	16.84	21.31	0.091	0.142	0.223	6.06	9.46	14.89
T_{11}: Zn (1 g/l) + Fe (1 g/l) + Si (0.1%)		10.19	13.09	17.58	22.42	0.097	0.150	0.242	6.44	9.97	16.14
T_{12}: Control		8.95	11.20	14.81	18.24	0.075	0.120	0.171	5.00	8.03	11.41
S.Em. ±	Y	0.09	0.15	0.22	0.33	0.004	0.002	0.006	0.25	0.15	0.37
	T	0.24	0.37	0.54	0.82	0.009	0.006	0.014	0.61	0.38	0.92
	Y × T	0.34	0.52	0.76	1.15	0.013	0.008	0.020	0.87	0.54	1.30
C. D. at 5%	Y	0.28	0.43	0.63	0.95	NS	NS	NS	NS	NS	NS
	T	0.68	1.05	1.54	2.32	NS	0.016	0.039	NS	1.09	2.62
	Y × T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%		5.73	6.78	7.38	8.73	23.03	9.21	13.56	23.03	9.21	13.56

Table 3: Effect of micronutrients and plant growth regulator on physiological parameters (RGR, total chlorophyll) of onion (*Allium cepa* L.) (Pooled value of two years)

Treatments		RGR (g/g/days)			Total chlorophyll (mg/g)			
		45-75 DATP	75-105 DATP	105 DATP-at harvest	45 DATP	75 DATP	105 DATP	At harvest
T_1: Zn (1 g/l)		0.0086	0.0100	0.0126	1.00	1.15	1.24	1.17
T_2: Fe (1 g/l)		0.0082	0.0099	0.0123	1.03	1.22	1.29	1.24
T_3: Zn (1 g/l) + Fe (1 g/l)		0.0086	0.0100	0.0126	1.02	1.19	1.29	1.22
T_4: GA_3 (100 mg/l)		0.0086	0.0101	0.0129	0.96	1.13	1.22	1.15
T_5: Si (0.1%)		0.0082	0.0098	0.0119	0.93	1.09	1.18	1.11
T_6: Zn (1 g/l) + GA_3 (100 mg/l)		0.0088	0.0100	0.0129	1.04	1.24	1.34	1.27
T_7: Fe (1 g/l) + GA_3 (100 mg/l)		0.0086	0.0099	0.0124	0.98	1.16	1.25	1.16
T_8: Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l)		0.0086	0.0100	0.0127	1.10	1.26	1.36	1.28
T_9: Zn (1 g/l) + Si (0.1%)		0.0085	0.0099	0.0125	0.90	1.06	1.13	1.09
T_{10}: Fe (1 g/l) + Si (0.1%)		0.0081	0.0097	0.0117	0.98	1.16	1.25	1.19
T_{11}: Zn (1 g/l) + Fe (1 g/l) + Si (0.1%)		0.0083	0.0098	0.0121	0.93	1.09	1.18	1.12
T_{12}: Control		0.0075	0.0093	0.0103	0.77	0.92	1.01	0.96
S.Em. ±	Y	0.0003	0.00004	0.0001	0.01	0.01	0.01	0.01
	T	0.0007	0.0001	0.0002	0.02	0.03	0.03	0.03
	Y × T	0.0010	0.0001	0.0004	0.03	0.04	0.04	0.04
C. D. at 5%	Y	0.0008	0.0001	NS	0.03	0.03	0.04	NS
	T	NS	0.0002	0.0008	0.07	0.08	0.09	0.09
	Y × T	NS	NS	NS	NS	NS	NS	NS
C.V.%		20.52	2.39	5.84	6.37	6.34	6.59	7.08

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

Treatments		Polar diameter of bulb (cm)	Equatorial diameter of bulb (cm)	Neck thickness of bulb (cm)	Average weight of bulb (g)	Marketable yield (t/ha)
T_1: Zn (1 g/l)		5.13	5.86	1.11	63.42	40.38
T_2: Fe (1 g/l)		4.84	5.73	1.12	62.66	39.89
T_3: Zn (1 g/l) + Fe (1 g/l)		5.32	5.94	1.06	70.61	44.95
T_4: GA_3 (100 mg/l)		5.11	6.10	1.19	65.33	41.59
T_5: Si (0.1%)		4.75	5.58	1.06	58.68	37.36
T_6: Zn (1 g/l) + GA_3 (100 mg/l)		5.54	6.22	1.11	71.67	45.62
T_7: Fe (1 g/l) + GA_3 (100 mg/l)		5.22	6.12	1.15	66.59	42.39
T_8: Zn (1 g/l) + Fe (1 g/l) + GA_3 (100 mg/l)		5.34	6.27	1.11	68.87	43.84
T_9: Zn (1 g/l) + Si (0.1%)		4.95	5.89	1.09	60.50	38.52
T_{10}: Fe (1 g/l) + Si (0.1%)		4.83	5.59	1.03	58.63	37.32
T_{11}: Zn (1 g/l) + Fe (1 g/l) + Si (0.1%)		5.13	5.92	1.08	61.42	39.11
T_{12}: Control		4.51	5.22	0.98	56.02	35.67
S.Em. ±	Y	0.05	0.05	0.01	0.98	0.62
	T	0.13	0.14	0.04	2.40	1.53
	Y × T	0.19	0.20	0.05	3.40	2.16
C. D. at 5%	Y	NS	NS	NS	2.80	1.78
	T	0.39	0.40	NS	6.86	4.37
	Y × T	NS	NS	NS	NS	NS
C.V.%		6.74	5.97	8.90	9.26	9.26

Conclusion

This study showed that treatment T_6 of Zn (1 g/l) + GA_3 (100 mg/l) at 30 and 60 days after transplanting increased the plant height, no. of leaves, total dry matter production, AGR, CGR, RGR, total chlorophyll, equatorial diameter, polar diameter of bulb, average weight of bulb and marketable yield of onion followed by treatment T_3 of Zn (1 g/l) + Fe (1 g/l). The findings of present investigation had given a clear cut message that foliar applications micronutrients and plant growth regulator were most effective, while technology adaptation may vary from season to season as governed by climatic/ environmental condition.

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