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INFLUENCE OF MACRONUTRIENTS AND MICRONUTRIENTS ON BIOCHEMICAL AND YIELD CONTRIBUTING TRAITS IN ONION (*ALLIUM CEPA* L.)

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ABSTRACT

Micronutrients are equally important as macronutrients in enhancing plant growth, yield and quality, especially for crops grown on reclaimed lands. Onions were cultivated in sandy soil under field conditions and subjected to varying rates of sulfur (S), boron (B) and zinc (Zn), either individually or in combination. A research trial was conducted to enhance onion growth performance and the quantitative and qualitative yield in response to applying micronutrients and macronutrients. To assess their impact on specific growth traits, micronutrient uptake, nitrogen absorption from mineral fertilizers and phosphorus and potassium uptake by the entire plant. Maximum bulb weight and yield were recorded with the application of FYM, NPK and sulfur with or without adding boron and zinc. No definite trend was noticed for nutrient application in onion for quality parameters like dry weight, total sugar, reducing sugar and TSS. Overall interpretation of the gathered data suggests that soil application of FYM @ 15 t/ha and NPK @125:100:100 kg/ha along with sulfur 40 kg/ha &/or foliar application of B (0.2%) &/or Zn (0.05%) twice at 30 and 50 days after transplanting increases onion bulb yield.

Key words : Onion, Micronutrient, Macronutrient, FYM, S, B and Zn.

Introduction

Onion (*Allium cepa* L.) is an important bulb vegetable of the Alliaceae family. Fresh, cooked, and processed forms of onion are widely used for their unique flavor or enhancement ability (El Ghamry *et al*., 2024). The genus Allium includes around 750 species out of which over 20 Allium species have been consumed by humans excluding the most important edible Alliums *i.e.* onion, Japanese onion, leak, and garlic (Van der Meer, 1971). Onion is considered the second most important vegetable crop grown in the world, next to tomato. It is an indispensable item in every kitchen as vegetables and condiments flavor many of the foodstuffs. Therefore, the onion is popularly known as the 'Queen of the kitchen' (Hossain *et al*., 2017). The onion bulb is rich in minerals, especially calcium, potassium, and phosphorus besides having fairly good quantities of carbohydrates, proteins and vitamin C. The bulb is composed of carbohydrates (11.0 g), proteins (1.2 g), fiber (0.6 g), moisture (86.8 g) and energy (38 cal.). Apart from these, vitamins like ascorbic acid (11 mg), thiamine (0.08 mg), riboflavin (0.01 mg), and niacin (0.2 mg) and minerals like phosphorus (39 mg), calcium (27 mg), sodium (1.0 mg), iron (0.7 mg) and potassium (1.57 mg) per 100 g of material (Fouda *et al*., 2016). Crop management addresses various agronomical issues. Under suitable agroclimatic conditions, nutrient management is an important factor that influences the growth and yield of onions to a great extent (Muluneh *et al*., 2024). It is possible to produce higher yields of good quality bulbs by judicious application of nutrients. Other

than major crop nutrients, sulfur is required in crops for pungency, oil contents and other quality parameters (El-Sherbeny *et al*., 2024). The application of sulfur fertilizer proved beneficial for onion crops in this region (Meher *et al*., 2016; Mondal *et al*., 2020). Boron is essential for plant growth and development. Adequate boron nutrition is critical for high yields and quality of crops. To study the effect of fertilizers on the growth, yield and quality of onion bulbs in response to the application of micronutrients and macronutrients.

Materials and Methods

The experiment was conducted in RVS Padmavathy College of Horticulture, Sampatti, Dindigul district, Tamil Nadu, India. The experimental site lies at 10 30 N latitude and 77 86 E longitude, with an altitude of 289—08 meters from the mean sea level. The soil has a sandy clay loam texture with a slightly neutral pH. The soil has having good drainage system and well-aerated soil. The experiment was conducted during May 2023 – July 2023. The average maximum temperature is about 32! and the average minimum temperature is about 19^0C. The annual rainfall of the district varies from 700 to 1600 mm. The Onion variety in the study was the Kamala variety of Dindigul with a crop duration of (70-80 days) and tolerant to high temperatures.

Design and layout

The experiment was laid out in Randomized Block Design (RBD) with one control involving eight treatments which is replicated thrice. A plot size of 2 × 2 meters was maintained for each replication. The treatment details are shown in Table 1.

Table 1 : Treatment details.

S. no.	Treatments	Treatment details
1	T_1	FYM @ 20 t/ha
2	T_2	FYM + NPK @125:100:100 kg/ha
3	T_3	FYM + NPK @125:100:100 kg/ha + S @40 kg/ha
4	T_4	FYM + NPK @125:100:100 kg/ha + B @ 0.2%
5	T_5	FYM + NPK @125:100:100 kg/ha + Zn @ 0.05%
6	T_6	FYM + NPK @125:100:100 kg/ha + S @ 40 kg/ha + B @0.2%
7	T_7	FYM + NPK @125:100:100 kg/ha + S@ 40 kg/ha + Zn@ 0.05%
8	T_8	FYM + NPK @125:100:100 kg/ha + S @ 40 kg/ha + B @ 0.2% + Zn @0.05%
9	T_9	Control

Yield parameters

Average Bulb weight (g)

The weight of the ten randomly tagged plant bulbs was recorded and an average of these were worked out and expressed in grams.

Bulb yield (t/ha)

After curing the bulb yield per plot was recorded. The bulb yield per hectare was worked out based on the plot yield.

Dry weight (%)

Randomly selected ten bulbs from each treatment were cut into small pieces with the help of a stainless-steel knife. A known weight of the sample was kept in a hot air oven at 58°C temperatures till a constant weight was obtained.

$$\text{Bulb dry matter percentage} = \frac{\text{Bulb dry weight (g)}}{\text{Bulb fresh weight (g)}} \times 100$$

Quality parameters

Total soluble solids (p brix)

The fresh onion juice was obtained with the help of a cork borer by introducing it up to the middle of the bulb from its horizontal position (Mc Collumn, 1968; Niewhof *et al*., 1973). The juice obtained was tested for brix value, an index of total soluble solids, with the help of a hand refractometer (0°-32° brix). The average brix of ten bulbs was worked out and expressed as degree brix.

Reducing sugar (%)

A reducing sugar is any sugar that is capable of acting as a reducing agent. In an alkaline solution, a reducing sugar forms some aldehyde or ketone, which allows it to act as a reducing agent. The conventional method for doing so is the Lane-Eynon method, which involves titrating the reducing sugar with copper(II) in Fehling's solution in the presence of methylene blue, a common redox indicator.

Total sugar (%)

Total Sugars include sugars naturally present in many nutritious foods and beverages, such as sugar in milk and fruits as well as any added sugars that may be present in the product. The total sugar content is calculated as the sum of the following lignocellulosic sugars: glucose, xylose, mannose, arabinose, galactose, and rhamnose.

The total sugars were estimated by the anthrone method suggested by

$$\text{Total sugars} = \frac{\text{Sugar values from graph (mg)}}{\text{Aliquot sample used}} \times \frac{\text{Total vol. of extract (ml)}}{\text{Wt. of the sample (mg)}} \times 100$$

Results and Discussion

The impact of macronutrients and micronutrient application on different parameters is discussed below. To sustain high productivity and quality of onion, judicious nutrient application is indispensable. The yield can be significantly increased with the combined use of different micronutrients along with the recommended dose of N, P, O_5 and K, O fertilizers. Thus, by keeping this point in view, an attempt has been made to investigate the different levels of micronutrients along with N, P_2O_5, K_2O and FYM for maximizing onion production and good soil health.

Average bulb weight (g) and Dry weight (%)

Data of mean of the fresh weight of the bulb have been presented in Table 2, which shows that T_6 (FYM+NPK+S+B) recorded the maximum bulb weight (64.60 g) followed by T_7(FYM+NPK+S+Zn) (64.20 g). The minimum bulb weight (51.12 g)was observed in T_9(Control). The application of Sulphur +Boronincreases the bulb weight more than other macro and micronutrients. This is due to the cumulative effect between N, P, K, Zn, S and B supplied together for the growth of onion. The supply of food is directly proportional to the rate of growth and development of the bulb. In onion, bulb development starts after 40 days of sowing. The assimilates stored in the leaves were utilized for increasing the bulb size of an onion. A similar trend was observed in the present investigation.

Dry weight percentage has differed significantly among the treatments shown in Table 2. In the crop, T_5(FYM+NPK+Zn) observed a higher Dry weight percentage (13.60 %) followed by T_6(FYM+NPK+S+B) (13.20%). The minimum weight percentage (7.54 %) was observed in T_9(Control). Marketable yield depends upon how much losses in total yield were observed due to premature bolting (twin bulbs and undersized bulbs) *i.e.* less than 35 mm bulb diameter. Apart from total yield the, marketable bulb yield is the most vital character on which market rates and income are mainly dependent. To obtain the marketable yield, the dry matter percentage is most important.

Plant height and Bulb yield (t/ha)

A perusal of the data of Table 3 and Fig. 1 indicated that plant height was affected by all treatments of macronutrients and Micronutrients as the highest plant height is observed in T_8 (22.50cm) followed by T_7 (21.17cm). The lowest plant height is registered in control plot T_9 (12.43cm). The T_8 (FYM + NPK + S + B + Zn) which has the higher plant height. As the micronutrients influence the plant height. Apical meristems are responsible for the increase in length, differentiation of various appendages and formation of plant tissues. The growth of plants is a vital process that brings about permanent changes in plants and their parts concerning their size, form, weight and volume. The supply of food is directly proportional to the rate of growth. The vigorous growth of onion in terms of plant height and some leaves per plant might be due to higher uptake of N, P_2O_5, K_2O and micronutrients like sulphur, zinc and boron. The significant differences among the treatments were observed. The application of chemical fertilizers in combination with micronutrients at different levels exerted a significant increase in growth parameters, like plant height. The stem grows in height by adding cell files at the base of the shoot apical meristem. Elongation of central pith cells below the leaf tip and spreads down the length of the unifacial blade. These cells are smaller and more

Table 2 : Effect of macronutrient and micronutrient on average bulb weight (g) and dry weight (%).

S. no.	Treatments	Average bulb weight (g)	Dry weight (%)
1.	T_1 - FYM @ 20 t/ha	54.17	9.40
2.	T-$_2$ – FYM+NPK	56.30	10.10
3.	T_3 – FYM+NPK+S	58.20	10.60
4.	T_4 – FYM+NPK+B	62.50	11.47
5.	T_5 – FYM+NPK+Zn	63.10	13.60
6.	T_6 – FYM+NPK+S+B	64.60	13.20
7.	T_7 – FYM+NPK+S+Zn	64.20	12.60
8.	T_8 – FYM+NPK+S+B+Zn	63.40	11.50
9.	T_9 – Control	51.12	7.54
	Mean	**59.73**	**11.11**
	SE. (D)	**0.95**	**0.25**
	CD (p=0.05)	**2.04**	**0.54**

Table 3 : Effect of macronutrient and micronutrient on plant height and Bulb yield (t/ha).

S. no.	Treatments	Plant height (cm)	Bulb yield (t/ha)
1.	T_1 - FYM @ 20 t/ha	15.33	16.30
2.	T-$_2$ – FYM+NPK	16.27	17.77
3.	T_3 – FYM+NPK+S	17.33	18.60
4.	T_4 – FYM+NPK+B	18.00	19.50
5.	T_5 – FYM+NPK+Zn	18.50	20.60
6.	T_6 – FYM+NPK+S+B	19.33	22.10
7.	T_7 – FYM+NPK+S+Zn	21.17	21.30
8.	T_8 – FYM+NPK+S+B+Zn	22.50	21.10
9.	T_9 – Control	12.43	13.75
	Mean	**17.87**	**19.00**
	SE. (D)	**0.40**	**0.41**
	CD (p=0.05)	**0.86**	**0.87**

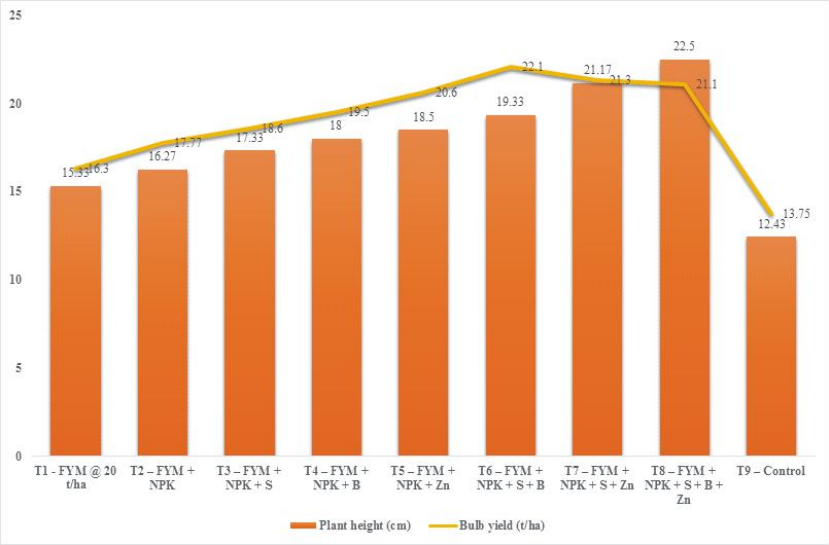

Fig. 1 : Plant height and bulb yield of onion sprayed with different concentrations of macro and micronutrients.

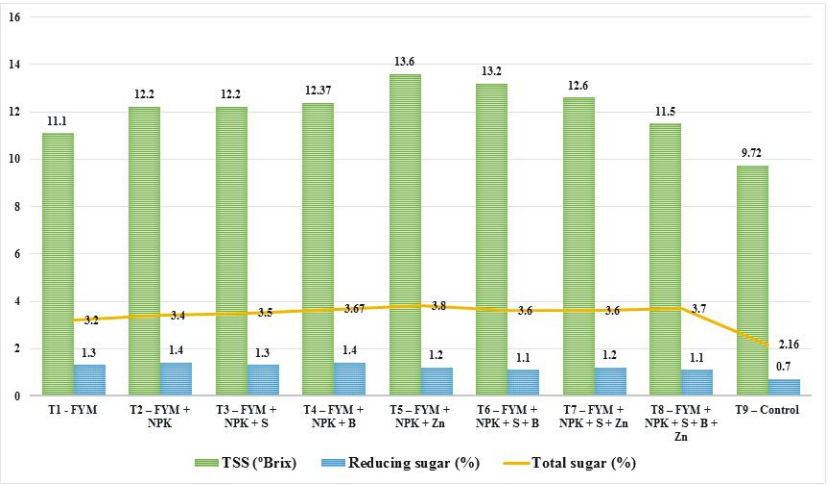

Fig. 2 : TSS, Reducing sugar and Total sugar of onion sprayed with different concentrations of macro and micronutrients.

densely staining in the early phase of leaf morphogenesis (Brewster and Rabinowitch, 1990). The results of the present investigation revealed that micronutrient applications showed significant variation at different growth stages. The foliar application of B and Zn significantly improved the plant height by applying micronutrients.

The interaction table revealed the maximum bulb yield (22.10 t/ha) was observed in T_6(FYM+NPK+S+B). It is followed by 21.30 t/ha in T_7 (FYM+NPK+S+Zn). The lowest yield (13.75 t/ha) was observed in the Control plot (T_9). The increase in yield could be due to better uptake of nutrients from soil which might have contributed to increased plant height, number of leaves, bulb diameter and weight of bulb that ultimately enhanced the yield. The micronutrient mixture consists of B-0.2%, Zn 0.05% and S@40kg/ha. All the micronutrients have a combined effect on the growth and development of onion and that leads to the highest total yield as compared to other treatments. The soil application of micronutrient mixture was found as a better treatment followed by the foliar application of micronutrient mixture and soil application of zinc sulfate in the present investigation. The past research workers *i.e.* Baghel and Sarnaik (1986), Mishra *et. al*. (1986), Bhonde *et al*. (1995), Ballah and Rana (2012), Rao and Deshpande (1971) also reported that the combined use of micronutrient mixture gives the higher yield as compared to the recommended dose of fertilizers to onion crop.

TSS (°Brix), reducing sugars (%) and Total sugar (%)

The results revealed that the total soluble solids (TSS) of onion bulbs were significantly influenced by the application of various micronutrients along with the recommended dose of NPK and FYM revealed in Table 4 and Fig. 2. Treatment of fertilizer mixture (NPK) macronutrients along with Zn application showed an effective role in total soluble solids content in the bulbs. T_5 showed higher TSS content (13.60^0 Brix) followed by T_6 (13.20^0 Brix). The lowest TSS content (9.72^0 Brix) was obtained in T_9(Control). The increase in total soluble solids (TSS) was due to enhanced physiological activity, availability of nutrients and development of a strong source and sink relationship. These results conformed with the findings of Singh and Dhankar (1989), Quareshi and Lawande (2006).

The differences in the treatments were significant among the treatments. The differences in the treatments were significant among the treatments shown in Table 4. In the crop, T_4 (FYM+NPK+B) has a higher reducing sugar content (1.4%) followed by T_9 (Control) (0.7%). The lowest reducing sugar content was observed in T_6 (FYM+NPK+S+B) and T_8(FYM+NPK+S+B+Zn) (1.1%). Reducing sugars are those sugars that have a free aldehyde or a free ketone group due to the presence of the free functional group, these sugars can act as a reducing agent. Some common examples include glucose, fructose, galactose, *etc*. Onion stores the excess of phloem sap that has been produced by the leaves during photosynthesis. The most abundant sugar produced by

Table 4 : Effect of macronutrient and micronutrient on TSS (ºBrix), Reducing sugars (%) and Total Sugar (%).

S. no.	Treatments	TSS (ºBrix)	Reducing sugar (%)	Total sugar (%)
1.	T_1 - FYM	11.10	1.3	3.20
2.	T-$_2$ – FYM+NPK	12.20	1.4	3.40
3.	T_3 – FYM+NPK+S	12.20	1.3	3.50
4.	T_4 – FYM+NPK+B	12.37	1.4	3.67
5.	T_5 – FYM+NPK+Zn	13.60	1.2	3.80
6.	T_6 – FYM+NPK+S+B	13.20	1.1	3.60
7.	T_7 – FYM+NPK+S+Zn	12.60	1.2	3.60
8.	T_8 – FYM+NPK+S+B+Zn	11.50	1.1	3.70
9.	T_9 – Control	9.72	0.7	2.16
	Mean	**12.05**	**1.12**	**3.40**
	SE. (D)	**0.24**	**0.03**	**0.06**
	CD (p=0.05)	**0.52**	**0.06**	**0.12**

plants during photosynthesis is glucose. Glucose has a free aldehyde group and behaves as a reducing agent. Onion bulbs possess significant concentrations of soluble carbohydrates, primarily reducing sugars (fructose and glucose), sucrose and fructus. Concentrations of specific carbohydrates change during storage, attributable primarily to dehydration and the activities of fructanexohydrolases, as the onion bulb emerges from dormancy, it is influenced by sulphur and boron (Benkeblia *et al*., 2005).

The differences in the treatments of total sugars were found to be significant among the treatments shown in Table 4. In the crop, T_5 (FYM+NPK+Zn) has the highest total sugar content (3.80%) followed by T_6(FYM+NPK+S+B) and T_7(FYM+NPK+S+Zn). The lowest total sugar (2.16%) was observed in T_9(Control). Total sugars include sugars naturally present in many nutritious foods and beverages, such as sugar in milk and fruits as well as any added sugars that may be present in the product. There is no daily Value for total sugars because no recommendation has been made for the total amount to eat in a day. Carbohydrates make up about (9–10%) of both raw and cooked onions. They consist mostly of simple sugars, such as glucose, fructose and sucrose, as well as fiber. The differences in the treatments were found to be significant.

Conclusion

The onion is cultivated and used all around the world, and as its demand keeps on growing the production must also be improved. From the cultivation of onion, it could be concluded that FYM + NPK @125:100:100 kg/ha + S @ 40 kg/ha + B @ 0.2% + Zn @ 0.05% was found superior for not only increasing the bulb yield but also improved soil fertility and quality of onion bulb. In this treatment, the boron is used to improve the bulb size and bulb weight. The zinc and sulphur are used in improving the pungency and quality of onion and finally, the NPK provides the basic nutrients required for plant growth. So finally, we conclude that (T_8) FYM + NPK @125:100:100 kg/ha + S @ 40 kg/ha + B @ 0.2% + Zn @ 0.05% is the best treatment than others. These findings may be studied for further confirmation and the technology can be recommended for commercial cultivation.

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