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Influence of zinc and sulphur on growth and yield attributes of Onion (*Allium cepa* L.) cv. Bhima Super under Western Uttar Pradesh conditions

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ABSTRACT

A field experiment was conducted during the winter season of 2022-23 at the Horticulture Research Farm, Janta Vedic College, Baraut, Baghpat (U.P.), India, to evaluate the combined influence of zinc and sulphur on the growth and yield attributes of onion (*Allium cepa* L.) cv. 'Bhima Super' under Western Uttar Pradesh conditions. The experiment was laid out in a Randomized Block Design (RBD) with nine treatments along with a control and replicated trice: T_0 (Control), T_1 (100% NPK), T_2 (RDF + Zn 30 kg/ha), T_3 (RDF + Zn 20 kg/ha), T_4 (RDF + S 45 kg/ha), T_5 (RDF + S 30 kg/ha), T_6 (RDF + Zn 20 + S 30 kg/ha), T_7 (RDF + Zn 20 + S 45 kg/ha), T_8 (RDF + Zn 30 + S 30 kg/ha), and T_9 (RDF + Zn 30 + S 45 kg/ha). The results revealed that the integrated application of zinc and sulphur significantly enhanced all studied parameters. The treatment T_9 (RDF + Zn 30 kg/ha + S 45 kg/ha) emerged as the most effective, recording the maximum plant height (49.92 cm), stem length (8.49 cm), number of leaves (8.03), leaf length (41.43 cm), and neck thickness (1.79 cm). Furthermore, yield attributes were significantly superior in T_9, including polar diameter (5.11 cm), equatorial diameter (6.02 cm), bulb fresh weight (52.11 g), bulb dry weight (14.15 g), total soluble solids (12.26°Brix), leaf dry weight (16.80 g), and bulb weight per plot (9.05 kg). The highest total bulb yield (278.55 q/ha) was also recorded under the T_9 treatment. The study concludes that the application of RDF supplemented with 30 kg/ha zinc and 45 kg/ha sulphur is highly effective for optimizing onion productivity under the agro-climatic conditions of Western U.P. and the Delhi NCR region.

KEYWORDS

NPK, RDF, Onion, Western U.P. Condition, Growth, Yield

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Vegetables are indispensable components of the human diet, serving as primary sources of essential vitamins, minerals, and dietary fiber. Due to their significant nutraceutical value and role in preventing micronutrient deficiencies, they are often categorized as "protective foods". On the global stage, India maintains a prominent position as the second-largest producer of vegetables, trailing only China (NHB, 2023). Among various vegetables, onion (*Allium cepa* L.), popularly referred to as the "Queen of the Kitchen," occupies a prominent position owing to its remarkable culinary versatility and well-recognized medicinal properties.

India ranks second globally in onion production, with Maharashtra leading the domestic output, contributing approximately 13,301.70 thousand tonnes (42.73% shares) in 2021-22, followed by states like Gujarat, Karnataka, and Uttar Pradesh (Anon, 2023). Despite high production volumes, the productivity and quality of onions are frequently limited by nutrient imbalances. Recent soil health assessments have highlighted a widespread deficiency of essential secondary and micronutrients across Indian soils, particularly Sulphur (S) and Zinc (Zn) (Shukla *et al*., 2016). Sulphur is a critical element for *Allium* species, as it is a fundamental constituent of sulphur-containing amino acids (cysteine and methionine) and is responsible for the characteristic pungency and flavor of the bulbs. It positively influences vital physiological functions, including nitrogen metabolism, enzymatic activities, and protein synthesis, thereby enhancing both yield and bulb quality (Judita *et al*., 2014).

Furthermore, the quality of onion bulbs is defined by parameters such as Total Soluble Solids (TSS) and Dry Matter Content (DMC), which are positively correlated and dictate the post-harvest shelf life and processing value of the crop (Jongtae *et al*., 2016). Alongside Sulphur, Zinc plays a pivotal role in various metabolic processes, acting as a catalyst for carbonic anhydrase and a precursor for auxin synthesis, which are essential for robust vegetative growth and higher reproductive yield. Given the agro-climatic conditions of Western Uttar Pradesh and the increasing reports of multi-nutrient deficiencies in the region, there is an urgent need to optimize the application of these nutrients. Therefore, the present investigation was undertaken to evaluate the synergistic effect of Zinc and Sulphur on the growth and yield attributes of onion cv. 'Bhima Super'.

Materials and Methods

The present investigation was carried out during the Rabi season of 2022-23 at the Horticulture Research Block, Janta Vedic College, Baraut, Baghpat, Uttar Pradesh (29.1058°N, 77.2661°E), representing the agro-climatic conditions of the Delhi NCR region. The experiment was laid out in a Randomized Block Design (RBD) featuring nine treatments and one control replicated trice: T_0 (control), T_1 (100% RDF), T_2 (RDF + Zn 30 kg/ha), T_3 (RDF + Zn 20 kg/ha), T_4 (RDF + S 45 kg/ha), T_5 (RDF + S 30 kg/ha), T_6 (RDF + Zn 20 + S 30 kg/ha), T_7 (RDF + Zn 20 + S 45 kg/ha), T_8 (RDF + Zn 30 + S 30 kg/ha), and T_9 (RDF + Zn 30 + S 45 kg/ha). Nursery preparation commenced on October 13, 2022, utilizing rai sed beds (1 m width and 15-22.5 cm height) treated with Thiram @ 0.2% (4-5 g/m²) for soil sterilization. Seeds of onion cultivar 'Bhima Super' were sown in lines spaced 5-7 cm apart, covered with fine powdered FYM, and managed with regular rose-cane irrigation. Healthy, six week old seedlings were transplanted into the experimental field on January 1, 2023, at a spacing of 15 × 10 cm. Nutrient requirements were met through the application of urea, single super phosphate (SSP), and muriate of potash (MOP) to supply nitrogen, phosphorus, and potassium, respectively. Standard cultural practices, including uniform irrigation, weeding, and plant protection measures, were strictly followed. Data were recorded on various growth parameters, including plant height, stem length, leaf length, number of leaves, and neck thickness, alongside yield attributes such as polar and equatorial diameter, bulb fresh and dry weight, leaf dry weight, and total soluble solids (TSS). Total bulb yield was calculated both per plot (kg) and per hectare (q). All collected data were subjected to statistical analysis using ANOVA for Randomized Block Design, following the methodology described by Gomez and Gomez (1984), to determine the significance of the treatments.

Results and Discussion

Growth Attributes

The data presented in table 1 clearly indicate that the growth parameters of onion were significantly influenced by the combined application of zinc and sulphur. Among the treatments, T_9 (RDF + Zn 30 kg/ha + S 45 kg/ha) recorded the maximum plant height (49.92 cm), which was statistically at par with T_8 (RDF + Zn 30 kg/ha + S 30 kg/ha) showing a plant height of 47.30 cm. The minimum plant height (33.19 cm) was observed under the control treatment (T_0). A similar trend was observed for stem length, where the highest value (8.49 cm) was recorded in T_9, followed by T_8 (7.74 cm), while the lowest stem length (4.40 cm) was noted in the control (T_0).

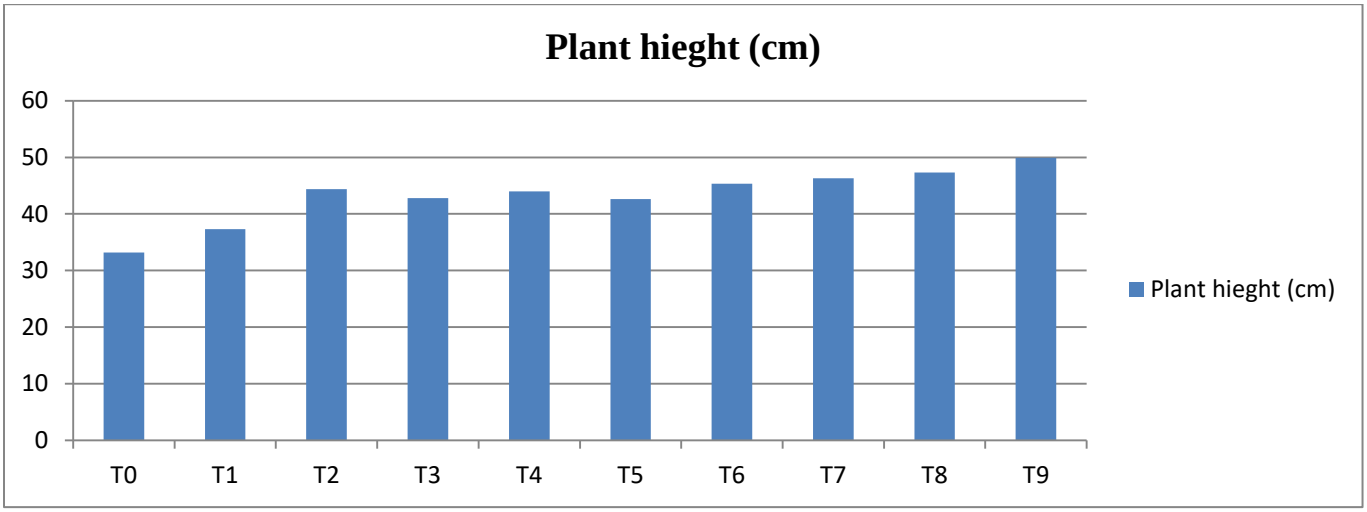

Fig 1. Effect of zinc and sulphur on plant height of onion cv. Bhima Super

Leaf development parameters also showed a significant response to nutrient application. Treatment T_9 produced the maximum number of leaves per plant (8.03) as well as the greatest leaf length (41.43 cm), followed closely by T_8, whereas the lowest values for these parameters were recorded in T_0. Neck thickness exhibited a comparable pattern, with the highest value (1.79 cm) recorded in T_9, which remained statistically at par with T_8 (1.69 cm). In contrast, the minimum neck thickness (1.20 cm) was observed in the control treatment. The enhanced growth observed under higher levels of zinc and sulphur may be attributed to the vital role of zinc in promoting cell division, meristematic activity, and cell elongation, along with its involvement in enzymatic activation and auxin synthesis, which collectively contribute to improved vegetative growth (Chhipa, 2005).

Furthermore, the increased number of leaves likely enhanced the photosynthetic efficiency of the plant, leading to better assimilation and utilization of nutrients. These findings are in close agreement with earlier reports by (Nagaich *et al*., 1999, Jaggi, 2005 and Tripathi *et al*., 2013).

Yield Attributes

The data presented in table 2 revealed that yield and its contributing characters were significantly influenced by the application of zinc and sulphur. The maximum polar diameter (5.11 cm) was recorded in treatment T_9 (RDF + Zn 30 kg/ha + S 45 kg/ha), which was statistically at par with T_7 (RDF + Zn 20 kg/ha + S 45 kg/ha) having a polar diameter of 4.95 cm.

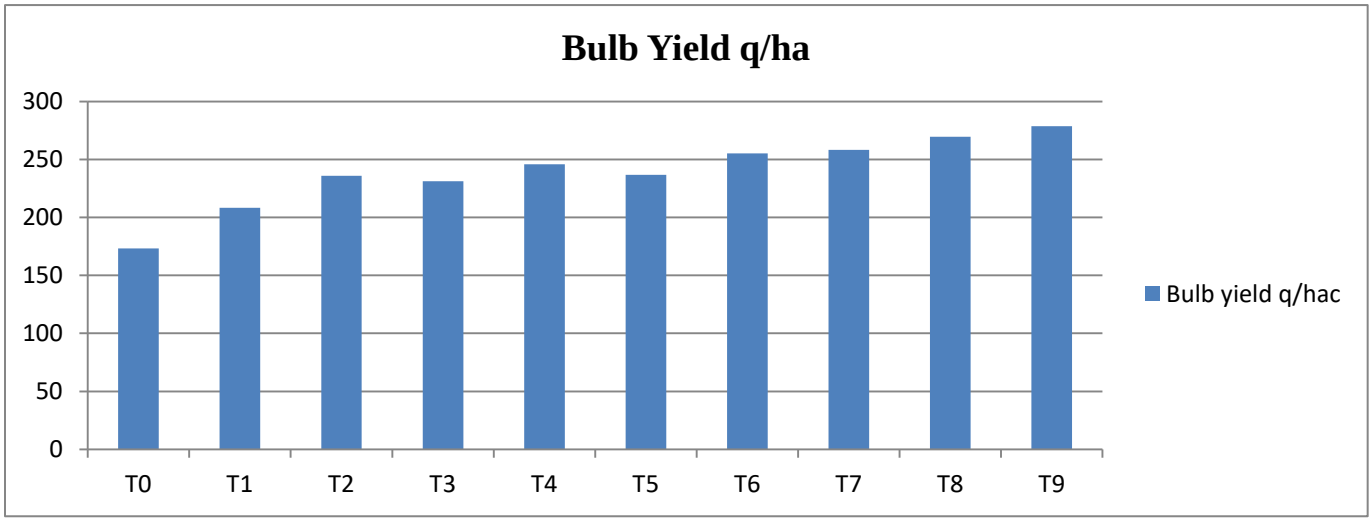

Fig 2. Effect of zinc and sulphur on bulb yield ha^{-1} of onion cv. Bhima Super

Table 1. Effect of Zink and Sulphur on growth attributes of onion cv. Bhima Super

Treatments		Plant Height (cm)	Stem Length (cm)	Number of Leaves/ Plant	Leaf Length (cm)	Neck Thickness (cm)
T_0	Control	33.19	4.40	5.17	28.79	1.20
T_1	100% NPK	37.29	5.34	5.91	31.96	1.34
T_2	100% NPK + Soil App. of Zinc 30kg/ha	44.40	6.85	6.89	37.54	1.53
T_3	100% NPK + Soil App. of Zinc 20kg/ha	42.81	6.17	6.29	36.64	1.55
T_4	100% NPK + Soil App. of Sulphur 45kg/ha	43.98	6.78	7.07	37.20	1.66
T_5	100% NPK + Soil App. of Sulphur 30kg/ha	42.61	6.27	6.56	36.44	1.56
T_6	100% NPK + Soil App. of Zn 20kg + S 30kg/ha	45.33	6.94	6.92	38.39	1.61
T_7	100% NPK + Soil App. of Zn 20kg + S 45kg/ha	46.28	7.45	7.13	38.74	1.65
T_8	100% NPK + Soil App. of Zn 30kg + S 30kg/ha	47.30	7.74	7.59	39.55	1.69
T_9	100% NPK + Soil App. of Zn 30kg + S 45kg/ha	49.92	8.49	8.03	41.43	1.79
CD (p = 0.05)		0.848	0.681	0.545	1.003	0.108

Table 2. Effect of Zink and Sulphur on quality and yield attributes of onion cv. Bhima Super

Treatment		Polar Diameter (cm)	Equatorial Diameter (cm)	Bulb Weight (gm)	Dry Weight of Bulb/ 100 gm Fresh Bulb	TSS of Onion (^{0}Brix)	Dry Matter of Leaves/ 100 gm Fresh Leaves	Yield kg/Plot
T_0	Control	3.9	4.12	35.00	10.92	9.53	9.86	5.63
T_1	100% NPK	4.11	4.43	42.08	11.79	10.44	13.75	6.77
T_2	100% NPK+ Soil App. of Zinc 30kg/ha	4.34	4.79	47.68	12.58	10.87	14.46	6.67
T_3	100% NPK+ Soil App. of Zinc 20kg/ha	4.25	4.53	46.70	12.44	10.83	15.33	7.51
T_4	100% NPK + Soil App. of Sulphur 45kg/ha	4.70	5.04	48.61	12.73	11.44	15.14	7.99
T_5	100% NPK + Soil App. of Sulphur 30kg/ha	4.51	4.74	47.82	12.72	10.90	15.15	7.69
T_6	100% NPK+ Soil App. of Zn 20kg + S 30kg/ha	4.72	5.35	49.95	13.11	11.13	15.06	8.29
T_7	100% NPK + Soil App. of Zn 20kg + S 45kg/ha	4.95	5.94	50.09	13.31	11.67	15.16	8.39
T_8	100% NPK+ Soil App. of Zn 30kg + S 30kg/ha	4.83	5.69	50.31	13.59	11.59	16.03	8.76
T_9	100% NPK+ Soil App. of Zn 30kg + S 45kg/ha	5.11	6.02	52.11	14.15	12.26	16.80	9.05
C.D.(p = 0.05)		0.171	0.391	0.929	0.792	0.570	0.904	0.550

The minimum polar diameter (3.90 cm) was observed under the control (T_0). Similarly, the equatorial diameter was highest in T_9 (6.02 cm), which remained at par with T_7 (5.94 cm), while the minimum value (4.12 cm) was recorded in the control treatment. Bulb weight was also significantly affected, with the maximum bulb fresh weight (52.11 g) observed in T_9.

The same treatment recorded the highest bulb dry weight (14.15 g) and maximum total soluble solids (12.26°Brix), whereas the lowest values for these parameters were noted in the control. Leaf dry weight followed a similar trend, with the highest value (16.80 g) recorded under T_9. The maximum bulb yield per plot (9.05 kg) was also obtained in T_9, while the minimum yield per plot (5.63 kg) was recorded in T_0.

A similar pattern was observed for total bulb yield per hectare, where T_9 recorded the highest yield (278.55 q/ha), significantly outperforming the control, which produced only 173.22 q/ha (fig 2). The enhanced yield under higher levels of zinc and sulphur may be attributed to the synergistic effect of sulphur with other essential nutrients, particularly nitrogen, which improves bulb development and increases bulb weight. Balanced nutrient supply promotes better growth and efficient translocation of photosynthates towards bulb formation, ultimately resulting in higher yield. Similar findings have been reported by (Prasad and Kumar, 2010; Rathod *et al*., 2020).

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