

Effects of zinc, dates, and cultivars on onion (*Allium cepa*) performance

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ABSTRACT

At Sri Karan Narendra Agriculture University's horticulture farm in Jobner, Jaipur, Rajasthan, an experiment was carried out during the winter (rabi) seasons of 2020–21 and 2021–22 to ascertain the impact of transplanting date, cultivar, and zinc application method on onion (*Allium cepa* L.) growth, yield, and quality. The split-plot design of the experiment was used, and it was repeated three times. Two transplanting dates—December 10 and January 1—as well as three cultivars—RO-01, RO-59, and Bhima Shakti—were maintained in the main plot. Four zinc application techniques—control, soil application of ZnSO₄ @25 kg/ha, dipping onion seedlings in zinc solubilizer solution prior to transplanting, and foliage spraying of ZnSO₄ @0.5% at 30 and 45 days after transplanting—were maintained in the sub-plots. Plant growth, bulb output (416.8, 358.0, and 387.4 q/ha), and onion quality were all significantly greater on January 1st, the transplanting date. Bhima Shakti had much greater plant growth, bulb production (417.5, 358.4, and 388.0 q/ha), and onion quality than the other cultivars, yet these metrics were comparable to RO-59. In zinc application techniques, foliar treatment of ZnSO₄ @0.5% resulted in considerably increased plant growth, bulb production (41.5, 35.8, and 38.7 t/ha), and onion quality; nevertheless, these were found to be comparable with soil application of ZnSO₄. The transplanting of the Bhima Shakti cultivar on January 1st and the foliar spraying of ZnSO₄ at a rate of 0.5% were shown to have the potential to improve onion performance.

Keywords: Zinc, Yield, Growth, Transplanting Dates, and Cultivars

Introduction

The biennial bulb vegetable and spice crop known as onions (*Allium cepa* L.) is a member of the Alliaceae family. It is very nutritious, increases hunger, has a diuretic effect, lowers blood sugar, eases the feeling of heat, and lessens cardiovascular issues. Higher levels of calcium, phosphorus, proteins, and carbohydrates were found in onions (Bhattacharjee et al. 2013). Allyl propyl disulphide, which gives onions their pungency, was present. Crop performance is influenced by a variety of variables, including the timing of transplanting and the cultivars and fertiliser treatment technique. Early and late seedling transplantation, the adoption of inefficient indigenous cultivars, and inadequate nutrient levels all contribute to decreased onion output. Many studies have found a significant variation in the growth, production, and quality of onions due to cultivars and the timing of transplanting. Onions are typically transplanted on various dates in India, resulting in uneven growth. The ideal time to plant seeds in a nursery in North India is when

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3 College of Agriculture (Sri Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan), Kishangarh Bas, Alwar, Rajasthan; Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan. *The average daytime temperature is 24°C, the relative humidity is 58%, and the day is longer than ten hours. The corresponding author's email address is gulabchoudhary8796@gmail.com.

Additionally, cultivar-to-cultivar variations exist in crop growth and quality (Simon et al. 2014). Using better cultivars might significantly boost the growth of onion plants. The size, skin colour, pungency, and other characteristics of onion cultivars vary. Because of this, producers cannot employ management strategies alone to achieve the necessary onion growth and quality. When it comes to raising crop quality and yield, nutrients are crucial. In order to capture the market, it is crucial to increase the output of high-quality onions. It is often established that the greatest strategy for improving onion quality and foliage is judicious fertiliser control. Alloway (2008) states that zinc is required for the production of tryptophan, a precursor to indole acetic acid and an important component of plant starch metabolism. Foliar spraying was also successful in improving the

nutritional status for crop quality and rectifying deficiencies. Therefore, an experiment was designed to investigate how transplanting dates, cultivars, and zinc affected onion performance.

METHODS AND MATERIALS

In the winter, an experiment was carried out (rabi).

seasons of 2020–21 and 2021–22 at Sri Karan Narendra Agriculture University's horticultural farm at Jobner, Jaipur, Rajasthan. This location, which is in Rajasthan's agroclimatic zone 3-A semi-arid eastern plain zone, is close to Jaipur. The climate is tropical, with hot, dry summers and an arid to semi-arid climate. The agricultural production season had maximum mean temperatures of 39.9°C and 43.4°C, average relative humidity of 54.77 and 46%, and rainfall of 280.3 mm and 234.5 mm in 2020–21 and 2021–22, respectively. The soil was loamy sand with a pH of 8.2 and an electrical conductivity of 1.25 dS/m. Organic carbon (0.20%), available nitrogen (135.60 kg/ha), available phosphorus (16.50 kg/ha), available zinc (0.5 ppm), and available potassium (152.50 kg/ha) were all low in the soil. There were three replications and twenty-four treatment combinations in the split-plot design of the experiment. The first determinant was the transplanting dates, which were T1, December 10, and T2, January 1. The cultivars, which were C1, RO-01, C2, RO-59, and C3, Bhima Shakti, were grouped in major plots. The second component, zinc application techniques, was administered in sub-plots at four different levels: Z0, control; Z1, soil application of ZnSO₄ @25 kg/ha; Z2, seedling dipping in zinc solubilizer; and Z3, foliar spray of ZnSO₄ @0.5% at 30 and 45 days after transplanting (DAT). The top layer of soil was mixed with farmyard manure at a rate of 4 kg/m², and nursery beds of 3 m by 1 m were created. Before being seeded on October 10, 2020, and November 1, 2021, the seeds were treated with carbendazim (2 g/kg). The crop's optional NPK dosage was 100:50:100 kg/ha. Urea, a source of nitrogen, was administered at basal, 20, and 40 DAT in three equal splits, whereas DAP, a source of phosphorus, and Muriate of potash (MOP), a source of potassium (full dosage), were applied as basal doses at the time of sowing. On December 10, 2020 and 2021, and January 1, 2021 and 2022, healthy, uniform-sized seedlings measuring around 9–10 cm in height were transplanted at a row and plant spacing of 20 cm by 10 cm. Before transplanting, 25 kg ZnSO₄/ha was added to the soil in accordance with the treatment combination. A suspension of five millilitres of zinc solubilizer in one litre of water was made for seedling dipping. After 30 and 45 DAT, two foliar sprays of 0.5% ZnSO₄ were applied. In accordance with the package of practices, the crop was maintained and other cultural customs were carried out. Plant growth and bulb production were observed throughout harvesting, and quality metrics were assessed after harvest. Growth parameters included measuring the height of the plant from its base to the tip of its tallest leaf using a metre scale, counting the total number of leaves on five randomly chosen plants to determine the mean number of leaves per plant, estimating the chlorophyll content using the method described by Arnon (1949), and calculating the number of days needed for 50% neckfall from the transplanting date to 50% neckfall. The total amount of chlorophyll was computed as:

Total chlorophyll (mg/g) = $A (652) \times 29 \times \text{Total volume (ml)} / \alpha \times 1000 \times \text{Sample weight (g)}$, where A represents absorbance at certain wave lengths, α is the route length (1 cm), and 29 is a constant factor. The total yield of bulbs was computed as:

Total bulb yield (q/ha) = Total bulb yield (kg/plot) $\times$ 10,000/ Plot net area (m²) $\times$ 100

A hand refractometer was used to measure the total soluble solid (TSS), and pyruvic acid was used to measure the amount of allyl propyl disulphide in the bulb (Hort and Fisher 1971). To do this, crush 6 g of bulb material in 15 ml of phosphate buffer, then centrifuge for 15 minutes at 2500 rpm. Add 0.5 ml of DNPH solution to a 2 ml sample. After 20 to 30 minutes of incubation at 37°C, add 5 ml of NaOH solution, thoroughly mix, and then incubate for 10 minutes at room temperature. Finally, note the absorption at 610 nm. The analysis of variance (ANOVA) method was used to statistically analyse the experimental data, and the significance level was determined using the F-test at the 5% level.

OUTCOMES AND TALK

Growth characteristics: Transplanting date, cultivar, and zinc treatment technique had a significant impact on onion growth in terms of plant height, number of leaves per plant, chlorophyll content, and number of days until 50% neckfall in both years as well as in pooled analysis (Table 1). Compared to December 10th, the plant height (64.7, 63.3, and 64.0 cm), number of leaves per plant (10.0, 9.0, and 9.5), chlorophyll content in leaves (0.65, 0.57, and 0.61 mg/g), and days until 50% neckfall (114.6, 111.7, and 113.1). In a pooled mean study, the plant height, number of leaves per plant, and chlorophyll content were 23.7, 11.6, and 10.5% higher on January 1st than on December 10th. The beneficial environmental circumstances, especially the ideal temperature for seedling development, may be the reason for the higher growth attribute values under January 1st transplanting.

This allows for more effective use of the climatic elements. Environmental factors and the genetic composition of a particular variety affected the onion's growth and development throughout all stages. Aragie et al. (2023) reported similar results with onions. The choice of cultivar has a major impact on the growth characteristics. Compared to RO-01, Bhima Shakti cultivars showed significantly higher plant height (63.9, 61.4, and 62.7 cm), number of leaves/plant (9.9, 9.1, and 9.5), chlorophyll content (0.64, 0.59, and 0.61 mg/g), and number of days to 50% neckfall (114.7, 110.5, and 112.6), although the results were comparable to RO-59. Compared to RO-01, plant height, leaf count per plant, and chlorophyll content under Bhima Shakti were 19.3, 14.5, and 19.7% greater. The impacts of a variety's genetic composition under favourable climatic circumstances may be the likely cause of the increased growth parameters. This might ultimately result in stronger photosynthetic activities and an increase in the rate of plant cell division and enlargement. Aruna et al. (2021) and Rugi et al. (2022) have showed similar outcomes in onions. The zinc application strategy had a significant impact on the crop's response in terms of growth characteristics. Considerably greater plant height (64.7, 61.2, and 63.0 cm), number of leaves/plant (10.0, 9.3, and 9.6), chlorophyll content (0.65, 0.60, and 0.63 mg/g), and number of days to 50% neckfall (113.2, 110.1, and 111.7) recorded in foliar spray of ZnSO₄ over control and dipping zinc solubilizer, but remained comparable to soil application of ZnSO₄. Increased growth parameters may result from ZnSO₄'s stimulating influence on cell division and elongation. Zinc controls the concentration of auxin in plants, which is necessary for root growth and for boosting CO₂ absorption per leaf area unit, which raises photosynthesis and chlorophyll content. Therefore, ZnSO₄ applied topically enhanced onion growth and development. In addition to boosting auxin production, zinc also enhanced nutrient intake, which in turn boosted vegetative growth. Nama et al. observed the similar pattern of outcomes (2021). output characteristics: Zinc treatment technique, cultivar, and transplanting date all had a major impact on the overall bulb output of onions (Table 2). In 2020–2021, 2021–2022, and in pooled study, the total bulb yield (41.7, 35.8, and 38.7 t/ha) was observed to be considerably greater under the transplanting date of January 1st compared to December 10th. In a pooled study, the transplanting date of January 1st yielded 13.0% more bulbs than December 10th. The best photoperiod and mild growth temperatures during the early vegetative and bulb initiation phases, as well as a slightly higher temperature and longer photoperiod during the bulb development and maturity phases, may have contributed to the transplanted crop's highest yield on January 1st. Similar findings were also reported by Khan et al. (2020). The total bulb production under Bhima Shakti was not statistically different from the RO-59 cultivar, however it was much greater than under RO-01. In both years and in the pooled mean study, Bhima Shakti achieved bulb yields that were 16.5, 18.9, and 17.7% higher than RO-01. The average bulb weight across cultivars is correlated with genetic diversity, and variations have different production potentials as well as genetic and environmental interactions that affect biomass accumulation among different storage and vegetative sections. Therefore, the bulb's increased fresh weight owing to humus ingredients may have led the reserve food supplies to be transported down the drain. Yesiwas et al. had similar results (2023). When compared to the control and seedling dipping in zinc solubilizer, foliar treatment of ZnSO₄ @0.5% at 30 and 45 DAT produced noticeably better bulb yields; nevertheless, it was still comparable to soil application of ZnSO₄ at 25 kg/ha. In a pooled mean study, foliar treatment of ZnSO₄ @0.5% resulted in 17.7 and 8.2% higher bulb yields compared to control and seedling dipping in zinc solubilizer, respectively. Under foliar application of ZnSO₄, increased and balanced zinc availability may have improved nutrient absorption in the onion's organs and tissues, resulting in supply

Table 1 Effect of transplanting dates, cultivars and zinc on growth attributes of onion

Treatment	Plant height			Number of leaves/ plant			Chlorophyll content in leaves (mg/g)			Number of days to 50% neckfall		
	(cm)			At 90 DAT			At 60 DAT			.		
	At 90 DAT	At 90 DAT	At 90 DAT	At 90 DAT	At 90 DAT	At 90 DAT	At 60 DAT	At 60 DAT	At 60 DAT	2020–2021	2021–2022	Pooled
Transplanting date	21	2021–22	Pooled	21	2021–22	Pooled	21	2021–22	Pooled	21	22	
T1	52.8	50.6	51.7	8.7	8.1	8.4	0.54	0.51	0.52	121.7	118.0	119.9
T2	64.7	63.3	64.0	10.0	9.1	9.5	0.65	0.57	0.61	114.6	111.7	113.1
SEm+	1.1	1.2	0.8	0.1	0.1	0.1	0.01	0.01	0.01	1.7	1.6	1.2
CD (P=0.05)	3.6	3.7	2.4	0.4	0.4	0.3	0.02	0.03	0.02	5.3	5.1	3.4

Cultivar

C1	51.2	49.9	50.5	8.4	7.8	8.1	0.52	0.46	0.49	123.4	121.2	122.3
C2	61.2	59.6	60.4	9.7	8.9	9.3	0.63	0.57	0.60	116.3	112.9	114.6
C3	63.9	61.4	62.7	9.9	9.1	9.5	0.64	0.59	0.61	114.7	110.5	112.6
SEm+	1.4	1.4	1.0	0.2	0.2	0.1	0.01	0.01	0.01	2.1	2.0	1.4
CD (P=0.05)	4.4	4.5	2.9	0.5	0.5	0.3	0.03	0.04	0.02	6.5	6.3	4.2

Zinc application method

Z0	52.1	48.9	50.5	8.3	7.9	8.1	0.50	0.46	0.48	124.7	121.7	123.2
Z1	62.4	60.2	61.3	9.9	8.9	9.4	0.64	0.59	0.62	114.8	111.1	113.0
Z2	55.9	57.4	56.7	9.2	8.4	8.8	0.58	0.51	0.55	119.8	116.5	118.1
Z3	64.7	61.2	63.0	10.0	9.3	9.6	0.65	0.60	0.63	113.2	110.1	111.7
SEm+	1.3	1.4	1.0	0.2	0.1	0.1	0.01	0.01	0.01	1.8	1.8	1.3
CD (P=0.05)	3.9	4.1	2.8	0.4	0.4	0.3	0.02	0.02	0.02	5.1	5.2	3.6

DAT, Days after transplanting. Treatment details are given under Materials and Methods.

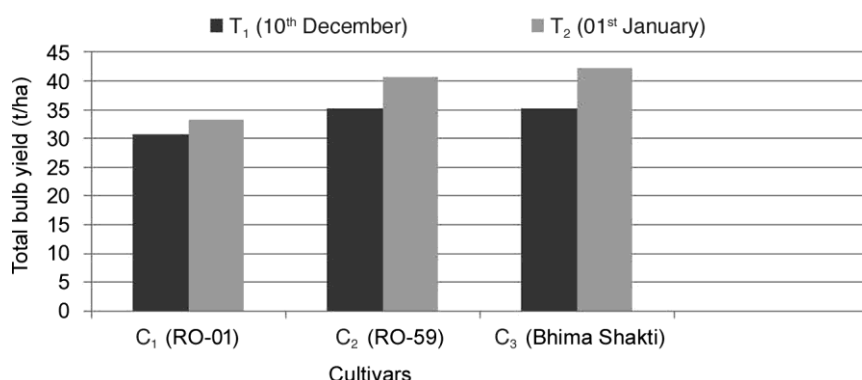


Fig 1 Interactive effects of transplanting dates and cultivars on total bulb yield (Pooled data).

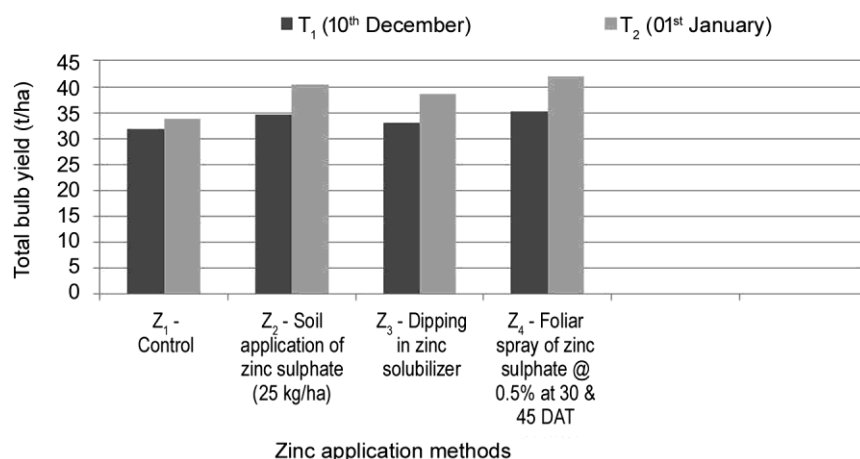


Fig 2 Interactive effects of transplanting dates and zinc on total bulb yield (Pooled data).

reduction of dietary deficits and availability of nutrients. The greater growth parameters allowed for more photosynthesis sites and the rerouting of photosynthates toward the sink. The similar tendency was seen in onions by Khatemenla et al. (2018). In a pooled mean study, transplanting date significantly interacted with cultivars and zinc administration techniques to affect total bulb output at harvest. Transplanting with Bhima Shakti (T2C3) on January 1st resulted in a significantly greater total bulb yield (42.3 t/ha) than the other treatment combinations, with the exception of transplanting with RO-59 (T2C2) on January 1st (Fig 1). Chandrakar et al. (2019) found similar findings. The overall bulb output was also shown to be significantly impacted by the interaction between zinc and transplanting dates (Fig 2). With the exception of transplanting

date 01 January and soil application of zinc sulphate @25 kg/ha (T2Z1), foliar application of zinc sulphate @0.5% at 30 and 45 DAT (T2Z3) resulted in a significantly better overall bulb yield (42.0 t/ha). Khan and Table 2 Effect of transplanting dates, cultivars and zinc on yield and quality attributes of onion

Treatment	Total bulb yield (t/ha)			Total soluble solids (°Brix)			Allyl propyl disulphide (mg/100 g)		
	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
Transplanting date									
T1	36.5	30.8	33.7	9.5	10.0	10.0	6.7	6.6	6.6
T2	41.7	35.8	38.7	10.9	11.1	11.0	8.0	7.8	7.9
SEm+	4.9	4.2	3.2	0.1	0.1	0.1	0.1	0.1	0.1
CD (P=0.05)	15.3	13.3	9.5	0.4	0.5	0.3	0.3	0.3	0.2
Cultivar									
C1	34.8	29.1	31.9	9.9	10.0	9.9	6.6	6.4	6.5
C2	40.8	35.1	37.9	10.6	10.7	10.7	7.7	7.5	7.6
C3	41.7	35.8	38.8	10.8	10.9	10.9	7.9	7.6	7.7
SEm+	6.0	5.2	3.9	0.7	0.2	0.1	0.1	0.1	0.1
CD (P=0.05)	18.8	16.3	11.6	0.5	0.6	0.4	0.4	0.4	0.3
Zinc application method									
Z0	35.8	29.9	32.9	9.7	9.8	9.7	6.7	6.4	6.5
Z1	40.5	34.7	37.6	10.8	11.0	10.9	7.8	7.7	7.7
Z2	38.6	32.9	35.8	10.4	10.4	10.4	7.1	6.8	7.0
Z3	41.5	35.8	38.7	10.9	11.2	10.9	7.9	7.8	7.8
SEm+	5.9	5.9	4.7	0.2	0.2	0.1	0.1	0.1	0.1
CD (P=0.05)	16.9	16.9	11.7	0.4	0.5	0.3	0.3	0.3	0.2

Treatment details are given under Materials and Methods.

al. (2020) reported the similar pattern of outcomes.

Quality characteristics: The transplanting date had an impact on the quality attributes in both years and in the pooled mean analysis, according to the results (Table 2). The results showed that, in compared to December 10th, the highest levels of total soluble solids (10.9, 11.1, and 11.0 °Brix) and allyl propyl disulphide (8.0, 7.8, and 7.9 mg/100 g) were obtained from January 1st transplantation. The improved TSS and APDS values under this treatment may be the consequence of excellent environmental circumstances during the transplanting on January 1st, which led to improved bulb growth and improved soil nutrient absorption. TSS and pungency in bulbs rose as a result. The new study's results support Poovamma et al.'s earlier findings (2021). Bhima Shakti was not statistically different from RO-59, although it did record considerably higher TSS (10.8, 10.9, and 10.9 °Brix) and APDS (7.9, 7.6, and 7.7 mg/100 g) than RO-01. This variety's somewhat greater trend of dry matter, volatile, and fatty oil content may be the cause of the enhanced TSS and APDS generation in bulbs. Ali et al. (2018) observed similar findings. Zinc application techniques had a major impact on bulb quality. Significantly higher levels of TSS (10.9, 11.2, and 10.9°Brix) and APDS (7.9, 7.8, and 7.8 mg/100g) were found when ZnSO₄ was applied topically at a rate of 0.5% compared to the control and when seedlings were dipped in zinc solubilizer; however, these levels were comparable when ZnSO₄ was applied topically at a rate of 25 kg/ha. This might be because of increased food availability and mobility, which hastened the conversion of complex polysaccharides into simple sugars and caused direct accumulation in growing bulbs. Zinc improved metabolic activities related to biosynthesis, including the production of carbohydrates. The similar pattern of findings was observed by Sethupathi et al. (2019) and Kumar et al. (2021).

It may be inferred that plant growth, bulb production, and quality were all greater on January 1st, the transplanting date. Bhima Shakti outperformed the other cultivars in terms of plant growth, bulb output, and quality, although the outcomes were comparable to those of RO-59. Regardless of the cultivar chosen or the date of transplanting, foliar spraying zinc sulphate provided further advantages when it came to the zinc treatment strategy. To improve onion growth, productivity, and quality, it is thus advised to transplant on January 1st using Bhima Shakti and apply a foliar spray of ZnSO₄ @0.5% at 30 and 45 DAT.

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