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

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ABSTRACT

An experiment was conducted during winter (*rabi)* seasons of 2020–21 and 2021–22 at Horticulture farm of Sri Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan to determine the effect of transplanting date, cultivar and zinc application method on growth, yield and quality of onion (*Allium cepa* L.). Experiment was conducted in split-plot design and replicated thrice. The treatments consist of 2 transplanting dates, viz. 10th December and 01st January; and 3 cultivars, viz. RO-01, RO-59 and Bhima Shakti were kept in main plot; and in sub- plots, 4 methods of zinc application, viz. control, soil application of $ZnSO_4$ @25 kg/ha, dipping of onion seedlings in zinc solubilizer solution before transplanting and foliage spray of $ZnSO_4$ @0.5% at 30 and 45 days after transplanting were kept. Significantly higher plant growth, bulb yield (416.8, 358.0 and 387.4 q/ha) and quality of onion were recorded in 01st January transplanting date. Among the cultivars, significantly higher plant growth, bulb yield (417.5, 358.4 and 388.0 q/ha) and quality of onion were recorded in Bhima Shakti but these parameters were at par with RO-59. In zinc application methods, significantly higher plant growth, bulb yield (41.5, 35.8 and 38.7 t/ha) and quality of onion were noticed under foliar application of $ZnSO_4$ @0.5% but these were found at par with soil application of $ZnSO_4$. Thus, the conclusion of findings was that the transplanting of Bhima Shakti cultivar on 01st January and with foliar application of $ZnSO_4$ @0.5% had the potential effect to increase onion performance.

Keywords: Cultivars, Growth, Transplanting dates, Yield, Zinc

Onion (*Allium cepa* L.) is a biennial bulb vegetable cum spice crop belongs to family Alliaceae. It is highly nutritive, promotes appetite, diuretic in nature, reduces cardiovascular problems, lowers blood sugar and relieves heat sensation. Onion contained higher calcium, phosphorus, proteins and carbohydrates (Bhattacharjee *et al.* 2013). Onion contained allyl propyl disulphide that cause pungency in it. The performance of crop depends on many aspects, among them, transplanting date and cultivars with fertilizer application method are important factors. Reduced onion yield is a result of early and late transplanting of seedling, use of ineffective local cultivars, and insufficient nutrient levels. Due to the date of transplanting and cultivars, numerous researchers around the world discovered a substantial variance in the growth, yield and quality of onions. In India, onion is transplanted on different dates in traditionally manner which show uneven growth. In North Indian conditions, the suitable time for sowing of seeds in nursery is when average day temperature is 24°C, relative humidity 58% and day length more than 10 hours.

Crop development and quality also differ from cultivar to cultivar (Simon *et al.* 2014). Onion plant growth could be increased substantially through use of improved cultivars. Onion cultivars are different in size, skin colour and pungency etc. Because of this, growers can't achieve desired onion growth and quality with solely management techniques. Nutrients play a significant role in increasing productivity and improving crops quality. Therefore, increasing the productivity of onion with quality is an important target to catch the market. It is well known that judicial management of nutrients is the best policy for the foliage and quality improvements of onion. According to Alloway (2008), zinc is necessary for synthesis of tryptophan, which is precursor of Indole Acetic Acid and plays a significant role in starch metabolism in plants. Foliar spray also made the success for correcting the deficits and improvements of the status of nutrients for quality of crop. Hence, on experiment was planned to study the impact of transplanting dates, cultivars and zinc on performance of onion.

MATERIALS AND METHODS

An experiment was conducted during winter (*rabi*)

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seasons of 2020–21 and 2021–22 at Horticulture farm of Sri Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan. This site located near Jaipur in Rajasthan and falls in agro climatic zone 3-A semi-arid eastern plain zone. Climate is tropical, arid to semi-arid with prominent hot dry summers. During crop production season, the maximum mean temperature was recorded 39.9ºC and 43.4ºC, average relative humidity 54.77 and 46% and rainfall was 280.3 mm and 234.5 mm in 2020–21 and 2021–22, respectively. The soil was loamy sand having electrical conductivity 1.25 dS/m and *p*H 8.2. The soil had low content of organic carbon (0.20%), available nitrogen (135.60 kg/ha), available phosphorous (16.50 kg/ha) and available zinc (0.5 ppm) and moderate in available potassium (152.50 kg/ha). The experiment was arranged in split-plot design with 3 replications and 24 treatment combinations. First factor, transplanting dates, comprised of 2 dates, viz. T_1, 10th December and T_2, 01st January and cultivars, comprised of 3 levels, viz. C_1, RO-01; C_2, RO-59 and C_3, Bhima Shakti were arranged in main plots. Second factor, zinc application methods, comprised of 4 levels, viz. Z_0, control; Z_1, soil application of $ZnSO_4$ @25 kg/ha; Z_2, dipping of seedling in zinc solubilizer and Z_3, foliar spray of $ZnSO_4$ @0.5% at 30 and 45 days after transplanting (DAT) were applied in sub-plots. The beds for nursery were prepared of size 3 m × 1 m and farmyard manure @4 kg/m^2 was added and mixed in the top layer of soil. The seeds were treated with carbendazim (2 g/kg) before sowing and sown on 10th October and 01st November of 2020 and 2021, respectively. The optional dose of NPK used for crop was 100: 50: 100 kg/ha. DAP as source of phosphorus and Muriate of potash (MOP) as source of potassium (full dose) was applied as basel dose at the time of sowing and urea as source of nitrogen was applied at basal, 20 and 40 DAT in 3 equal splits. Healthy, uniform size seedlings about 9–10 cm height were transplanted on 10th December of 2020 and 2021 and 01st January of 2021 and 2022 at 20 cm × 10 cm row and plant distance. As per treatment combination, 25 kg $ZnSO_4$/ha was mixed in soil before transplanting. For dipping seedlings suspension of 5 ml zinc solubilizer in 1 litre of water was prepared in the solution. Two foliar sprays of 0.5% of $ZnSO_4$ after 30 and 45 DAT were done. The crop was maintained and other cultural practices were done as per package of practices. Observations on plant growth, bulb yield were measured at harvesting and quality parameters were also measured after harvesting. Growth parameters, viz. plant height was measured from plant's base to tip of the highest leaf by meter scale, total numbers of leaves per plant were counted from randomly selected five plants to calculate the mean number of leaves per plant, chlorophyll content was estimated with the given method by Arnon (1949) and days required for 50% neckfall was calculated from transplanting date to 50% neck fall. Total chlorophyll content was calculated as:

$$\text{Total chlorophyll (mg/g)} = A_{(652)} \times 29 \times \text{Total volume (ml)}/\alpha \times 1000 \times \text{Weight of sample (g)}$$

where A, Absorbance at specific wave lengths; α is the path length = 1 cm and 29 = constant factor

Total bulb yield was calculated as:

$$\text{Total bulb yield (q/ha)} = \text{Total bulb yield (kg/plot)} \times 10{,}000/\text{Net area of plot (m}^2\text{)} \times 100$$

Total soluble solid (TSS) was determined with hand refractometer and allyl propyl disulphide content in bulb was determined as pyruvic acid (Hort and Fisher 1971). For this grind 6 g of bulb material in 15 ml of phosphate buffer and centrifuged at 2500 rpm for 15 min. Take a sample of 2 ml and add 0.5 ml DNPH solution. Incubate at 37°C for 20–30 min and add 5 ml of NaOH solution, mix well and incubate for 10 min at room temperature. At the end record the absorbance at 610 nm. Experimental data were statistically examined using the analysis of variance (ANOVA) approach, and the F-test at the 5% level of significance was used to determine level of significance.

RESULTS AND DISCUSSION

Growth attributes: Growth of onion in terms of plant height, number of leaves per plant, chlorophyll content and number of days to 50% neckfall was influenced significantly by transplanting date, cultivar and method of zinc application during both the years as well as in pooled analysis (Table 1). 01st January transplanting date recorded significantly higher plant height (64.7, 63.3 and 64.0 cm), number of leaves/plant (10.0, 9.0 and 9.5), chlorophyll content in leaves (0.65, 0.57 and 0.61 mg/g) and days to 50% neckfall (114.6, 111.7 and 113.1) in comparison to 10st December. 01st January transplanting date recorded 23.7, 11.6 and 10.5% more plant height, number of leaves per plant and chlorophyll content, respectively in comparison to 10st December transplanting in pooled mean analysis. The better values of growth attributes under 01st January transplanting might be due to the favourable environmental conditions particularly optimum temperature for seedling growth helps to utilize the climatic factors more efficiently. Genetic makeup of a given variety and environmental conditions influenced the growth and development of onion in all phases. Similar findings have also been recorded by Aragie *et al.* (2023) in onion. Cultivar selection significantly influenced the growth parameters. Bhima Shakti among cultivars recorded 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) in comparison to RO-01 but the results were at par with RO-59. Plant height, number of leaves per plant and chlorophyll content under Bhima Shakti were 19.3, 14.5 and 19.7% higher in comparison to RO-01. Probable reasons for enhanced growth parameters may be due to effects of varietal genetic makeup under positive environmental conditions which affects the foliage growth and finally lead to higher photosynthetic activities and increasing the rate of cell division and cell enlargement of plants. Similar results were also reported by Aruna *et al*. (2021) and Rugi *et al*. (2022) in onion. Significant response of crop in terms of growth parameters was influenced by zinc application method. Significantly higher 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 $ZnSO_4$ over control and dipping zinc solubilizer but remained at par with soil application of $ZnSO_4$. Increased in growth parameters might be due to stimulating effect of $ZnSO_4$ in division and elongation of cell. Zinc regulates the auxin concentration in plants which is needed for root development and increasing the absorption of CO_2 per leaf area unit and thus increased the chlorophyll content and photosynthesis. Hence, foliar application of $ZnSO_4$ improved the growth and development of onion. Besides, increased in the biosynthesis of auxin, zinc also promoted nutrient uptake that ultimately increased vegetative growth. The same trend of results was recorded by Nama *et al.* (2021).

Yield attributes: Total bulb yield of onion was significantly influenced by transplanting date, cultivar and zinc application method (Table 2). Total bulb yield (41.7, 35.8 and 38.7 t/ha) was reported significantly higher under 01st January transplanting date over 10th December during 2020–21, 2021–22 and in pooled analysis. 01st January transplanting date recorded 13.0% more bulb yield in comparison to 10th December in pooled analysis. The highest yield from the transplanted crop on January 01st may be attributable to the occurrence of mild growth temperatures and the ideal photoperiod during the early vegetative and bulb initiation phases and to a slightly higher temperature and longer photoperiod during the bulb development and maturity phases. Khan *et al.* (2020) also reported similar results. Total bulb yield was significantly higher under Bhima Shakti over RO-01 but was not significantly different from RO-59 cultivar. Bhima Shakti recorded 16.5, 18.9 and 17.7% more bulb yield in comparison to RO-01 during both the years and in pooled mean analysis. The probable reasons for that are varieties have varying production potentials as well as genetic and environmental interactions that influence biomass accumulation among various storage and vegetative portions, and the average bulb weight among cultivars is related to genetic variability. Therefore, the reserve food resources may have been moved to the drain due to the bulb's increased fresh weight caused by humus substances.

Similar findings were recorded by Yeshiwas *et al.* (2023). Under the zinc application methods, foliar application of $ZnSO_4$ @0.5% at 30 and 45 DAT recorded significantly higher bulb yield in comparison to control and dipping of seedling in zinc solubilizer but remained at par with soil application of $ZnSO_4$ at 25 kg/ha. Foliar application of $ZnSO_4$ @0.5% recorded 17.7 and 8.2% more bulb yield in comparison to control and dipping of seedling in zinc solubilizer, respectively in pooled mean analysis. Increased and balanced availability of zinc under foliar application of $ZnSO_4$ might has enhanced the uptake of nutrients in the organs and tissues of the onion which resulted in supply

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

Treatment	Plant height (cm)			Number of leaves/ plant			Chlorophyll content in leaves (mg/g)			Number of days to 50% neckfall		
	At 90 DAT			At 90 DAT			At 60 DAT			.		
	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
Transplanting date												
T_1	52.8	50.6	51.7	8.7	8.1	8.4	0.54	0.51	0.52	121.7	118.0	119.9
T_2	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												
C_1	51.2	49.9	50.5	8.4	7.8	8.1	0.52	0.46	0.49	123.4	121.2	122.3
C_2	61.2	59.6	60.4	9.7	8.9	9.3	0.63	0.57	0.60	116.3	112.9	114.6
C_3	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												
Z_0	52.1	48.9	50.5	8.3	7.9	8.1	0.50	0.46	0.48	124.7	121.7	123.2
Z_1	62.4	60.2	61.3	9.9	8.9	9.4	0.64	0.59	0.62	114.8	111.1	113.0
Z_2	55.9	57.4	56.7	9.2	8.4	8.8	0.58	0.51	0.55	119.8	116.5	118.1
Z_3	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.

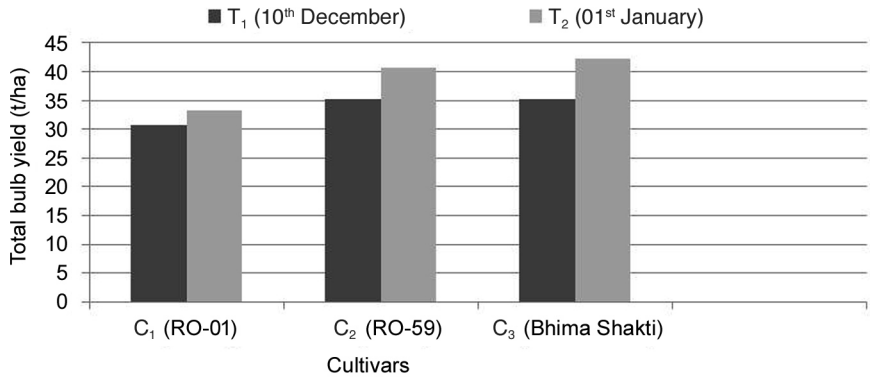

Fig 1 Interactive effects of transplanting dates and cultivars on total bulb yield (Pooled data).

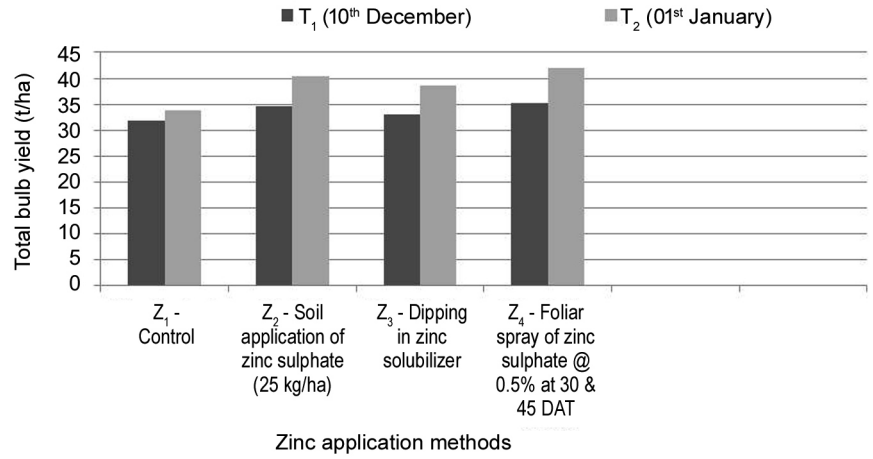

Fig 2 Interactive effects of transplanting dates and zinc on total bulb yield (Pooled data).

of nutrients in available form and decrease of the nutritional deficiencies. Greater photosynthesis sites and the redirection of photosynthates toward sink were made possible by the higher growth parameters. Khatemenla *et al.* (2018) in onion reported the same pattern. Transplanting date had a significant interaction effect with cultivars and zinc application methods on total bulb yield at harvest in pooled mean analysis. Significantly higher total bulb yield (42.3 t/ha), was recorded on 01st January transplanting with Bhima Shakti (T_2C_3) over rest of treatment combinations, except transplanting date 01st January with RO-59 (T_2C_2) (Fig 1). Similar results were reported by Chandrakar *et al*. (2019). Similarly, interactive effect of transplanting dates and zinc was found to have significant influence on total bulb yield (Fig 2). Significantly higher total bulb yield (42.0 t/ha) was recorded in transplanting date 01st January and foliar application of zinc sulphate @0.5% at 30 and 45 DAT (T_2Z_3) over rest of treatment combinations except transplanting date 01st January and soil application of zinc sulphate @25 kg/ha (T_2Z_1). Khan *et*

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 (^{0}Brix)			Allyl propyl disulphide (mg/100 g)		
	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
Transplanting date									
T_1	36.5	30.8	33.7	9.5	10.0	10.0	6.7	6.6	6.6
T_2	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									
C_1	34.8	29.1	31.9	9.9	10.0	9.9	6.6	6.4	6.5
C_2	40.8	35.1	37.9	10.6	10.7	10.7	7.7	7.5	7.6
C_3	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									
Z_0	35.8	29.9	32.9	9.7	9.8	9.7	6.7	6.4	6.5
Z_1	40.5	34.7	37.6	10.8	11.0	10.9	7.8	7.7	7.7
Z_2	38.6	32.9	35.8	10.4	10.4	10.4	7.1	6.8	7.0
Z_3	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) also reported same pattern of results.

Quality attributes: Results (Table 2) showed that transplanting date influenced the quality attributes during both the years as well as in pooled mean analysis. Results indicated that the maximum total soluble solids (10.9, and 11.1 and 11.0 °Brix) and allyl propyl disulphide (8.0, 7.8 and 7.9 mg/100 g) were recorded from 01st January transplanting date in comparison to 10th December. The better values of TSS and APDS under this treatment might be due to fact that favourable environment conditions prevailed during 01st January transplanting resulted in better bulb development that helped to absorb nutrients more efficiently from soil. This increased TSS and pungency in bulbs. The finding of the current study confirms the previous finding of Poovamma *et al*. (2021). Among cultivar treatment, Bhima Shakti recorded significantly maximum TSS (10.8, 10.9 and 10.9 °Brix) and APDS (7.9, 7.6 and 7.7 mg/100 g) over RO-01 but was not significantly different from RO-59. Increased in TSS as well as APDS might be due to characteristics of this variety that slightly increased trend of dry matters, volatile and fatty oil content resulting in significantly higher production of TSS and APDS in bulbs. Similar results were reported by Ali *et al.* (2018). Quality of bulbs was significantly influenced by zinc application methods. Significantly maximum TSS (10.9, 11.2 and 10.9 °Brix) and APDS (7.9, 7.8 and 7.8 mg/100g) was recorded in foliar application of $ZnSO_4$ @0.5% over control and dipping of seedling in zinc solubilizer but was at par with soil application of $ZnSO_4$ (25 kg/ha). This might be due to greater movement and availability of nutrients resulted in accelerated the breakdown of complex polysaccharides into simple sugars and direct accumulation in developing bulbs. Zinc enhanced metabolic processes involved in the biosynthesis processes such as carbohydrates. Sethupathi *et al.* (2019) and Kumar *et al.* (2021) reported same trend of results.

It may be concluded that 01st January transplanting date recorded higher plant growth, bulb yield and quality. Among the cultivars, Bhima Shakti provided the best performance in terms of plant growth, bulb yield and quality but results were at par with RO-59. In case of zinc application method, foliar spray of zinc sulphate gave additional benefits irrespective of the transplanting date and cultivar selection. Thus, 01st January transplanting date with Bhima Shakti and foliar spray of $ZnSO_4$ @0.5% at 30 and 45 DAT can be recommended for improving growth, productivity and quality of onion.

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