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Effect of transplanting dates, cultivars and zinc on yield and economics of onion in semi-arid conditions in Rajasthan

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ABSTRACT

Delayed transplanting and insufficient nutrient application are the major factors for reduced onion yield. Proper planting time is critical for getting optimal bulb yield. Selecting a suitable cultivar is one of the essential variables in getting higher growth and yield attributes for a particular agro-climatic condition. An experiment was conducted to determine the effect of transplanting date, cultivar and zinc application method on yield, yield attributes and economics of onion. Results were significant for all the yield attributes, yield and economics of onion. Transplanting on 01st January significantly increased the average bulb weight (81.10 g), equatorial diameter (5.58 cm), polar diameter (4.52 cm), total bulb yield (387.42 q/ha), net return (Rs 367963/ha) and B:C ratio (3.84) in a pooled analysis. Among the cultivars, significantly higher average bulb weight (79.37 g), equatorial diameter (5.48 cm), polar diameter (4.42 cm), total bulb yield (387.95 q/ha), net return (Rs 368680/ha) and B:C ratio (3.83) were recorded in Bhima Shakti. In zinc application methods, significantly higher average bulb weight (79.68 g), equatorial diameter (5.50 cm), polar diameter (4.42 cm), total bulb yield (386.67 q/ha), net return (Rs 364973/ha) and B:C ratio (3.78) was recorded with foliar spray of zinc sulphate @ 0.5 per cent at 30 & 45 DAT. The reduced neck thickness (0.70, 0.73 & 0.72 cm) was recorded on the 01st January transplanting, Bhima Shakti cultivar and foliar spray of zinc sulphate @ 0.5 per cent at 30 & 45 DAT, respectively.

Keywords: *Allium cepa* L., Bhima Shakti, RO-01, RO-59, Planting time, Zinc sulphate.

INTRODUCTION

Onion (*Allium cepa* L.) is a biennial bulb vegetable cum spice crop belonging to the family *Amaryllidaceae*. It is highly nutritive, promotes appetite and diuretic in nature, relieves heat sensation, lowers blood sugar and reduces cardiovascular problems. Nowadays, onion is great in demand as a bulb for table purposes as well as for products, like dehydrated flakes and powders usually made from white cultivars with high dry-matter content (Currah and Proctor, 5). In India, the area of onion cultivation is 1.62 million hectare with production of 26.64 million tonnes (Anonymous, 2). Among several management practices, transplanting date, cultivar and zinc application method are three important aspects for getting an optimum yield of the crop. Onion is a photosensitive crop and requires short-day conditions for bulb production in plains. Hence, the transplanting date plays a vital role to increase bulb yield (Misra *et al.,* 11). In North Indian conditions, the suitable time for sowing seeds in the nursery is when the average day temperature is 24 °C, relative humidity 58 per cent and day length of more than 10 hours.

Onion productivity could be increased substantially through the use of improved cultivars coupled with the optimum date of planting. Various cultivars of the same species grown even in the same environment give different yields as the performance of a cultivar mainly depends on the interaction of genetic makeup and environment. Therefore, cultivators are not able to get desired growth and yield of onion only by management practices. An adequate supply of nutrients is associated with vigorous vegetative growth and more efficient use of available inputs finally leads to higher productivity. Zinc is essential for synthesis of tryptophan, which is the originator of indole acetic acid which plays an important role in starch metabolism in plants (Alloway, *et al.,* 1). The proper applications of zinc need to be followed. Foliar application of fertilizers is an economical method to improve the yield and quality of bulb. Thus, foliar spraying is better as compared to soil application (Kinaci and Gulmezoglu, 10). The present investigation was conducted to know the effect of transplanting dates, cultivars and zinc on yield and yield attributes of onion.

MATERIALS AND METHODS

The experiment was conducted during 2020-21 and 2021-22 in *Rabi* season at Horticulture Farm, S.K.N. College of Agriculture, Jobner (26 °05' North latitude and 75°20' East longitude), located near

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Jaipur in Rajasthan (India). There were twenty-four treatment combinations consisting of two transplanting dates, *viz*. T_1: 10th December and T_2: 01st January and three cultivars, *viz*. C_1: RO-01; C_2: RO-59 and C_3: Bhima Shakti. Four zinc application methods *viz*. Z_0: control; Z_1: Soil application of $ZnSo_4$ @ 25 kg ha^{-1}; Z_2: dipping of seedling in 0.5% zinc solubilizer solution before transplanting and Z_3: foliar spray of $ZnSo_4$ @ 0.5 % at 30 & 45 days after transplanting (DAT) were applied in sub plots under split-plot design with three replications. Observations on yield attributes, namely average bulb weight, neck thickness, equatorial diameter, polar diameter and total bulb yield were recorded. Economics of production in different treatments were estimated after harvest of the crop. Data of experiment was statistical analysed by analysis of variance method as suggested by Panse and Sukhatme (15).

The total bulb yield and B:C ratio was calculated by using the formula given below:

Total bulb yield (q/ha) = [plot bulb yield (kg/plot) × 10,000/ Net area of plot (m^2)] × 100

BC ratio = net return (Rs) /total cost of cultivation (Rs)

RESULT AND DISCUSSION

Based on pooled mean analysis, results indicated that the better values of yield, yield attributes and economics of onion *i.e.*, average bulb weight (81.10 g), neck thickness (0.70 cm), equatorial diameter (5.58 cm), polar diameter (4.52 cm), total bulb yield (387.42 q ha^{-1}), net return (Rs 367963/ha) and B:C (3.84) ratio, were recorded from transplanting of onion seedling on 01st January than transplanting on 10th December (Table 2 and 3). The better values of yield, yield attributes and economics under these treatments might be due to favourable environment conditions such as average day temperature is 18-24 °C, relative humidity 60-70 per cent and day length more than 10 hours. The optimum conditons prevailing during initial growth phase resulted in good foliage growth and formation of ample canopy. This enabled to enhance photosynthesis, thereby, increasing dry matter accumulation, bulb weight as well as total bulbs yield per hectare (Singh *et al.,* 18). The higher values of net returns and B:C ratio under treatment transplanting of onion seedling on 01st January could be ascribed to the higher bulb yield of onion obtained under this treatment. These results are in close confirmation with the findings of Khan *et al.* (8) in onion and Savaliya *et al*. (17) in garlic.

Among the cultivars, Bhima Shakti recorded significantly better values of average bulb weight (79.37 g), neck thickness (0.73 cm), equatorial diameter (5.48 cm), polar diameter (4.42 cm), total

Table 1. Mean weekly weather parameters for the period of transplanting time (December-January of 2020 and 2021)

SMW* No.	Period	Temperature °C				Relative humidity (%)	
		Maximum		Minimum			
		2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
1.	Dec. 03 to Dec. 09	30.2	24.3	07.1	7.0	79	65
2.	Dec. 10 to Dec. 16	24.7	22.9	09.8	3.6	81	60
3.	Dec. 17 to Dec. 23	23.1	22.4	02.3	3.0	83	55
4.	Dec. 24 to Dec. 31	22.1	22.7	02.3	6.0	62	65
5.	Jan. 01 to Jan. 07	21.2	20.3	10.6	6.1	73	73
6.	Jan. 08 to Jan. 14	20.4	17.3	05.8	4.5	64	69
7.	Jan. 15 to Jan. 21	24.1	18.9	05.9	3.9	61	65
8.	Jan. 22 to Jan. 28	21.9	18.9	03.1	3.4	61	66
9.	Dec. 03 to Dec. 09	30.2	24.3	07.1	7.0	79	65
10.	Dec. 10 to Dec. 16	24.7	22.9	09.8	3.6	81	60
11.	Dec. 17 to Dec. 23	23.1	22.4	02.3	3.0	83	55
12.	Dec. 24 to Dec. 31	22.1	22.7	02.3	6.0	62	65
13.	Jan. 01 to Jan. 07	21.2	20.3	10.6	6.1	73	73
14.	Jan. 08 to Jan. 14	20.4	17.3	05.8	4.5	64	69
15.	Jan. 15 to Jan. 21	24.1	18.9	05.9	3.9	61	65
16.	Jan. 22 to Jan. 28	21.9	18.9	03.1	3.4	61	66

*SMW = Standard Meteorological Week, A = Average

Table 2. Effect of transplanting dates, cultivars and zinc on yield and yield attributes of onion (Pooled mean of two years).

Treatments	Average bulb weight (g)	Neck thickness (cm)	Equatorial diameter (cm)	Polar diameter (cm)	Total bulb yield (q ha^{-1})
Transplanting dates					
T_{1-} 10th December	67.18	0.88	4.78	3.70	336.87
T_{2-} 01st January	81.10	0.70	5.58	4.52	387.42
SEm±	0.78	0.01	0.04	0.04	3.22
CD (P=0.05)	2.30	0.02	0.12	0.12	9.50
Cultivars					
C_{1-} RO-1	64.93	0.90	4.69	3.60	319.43
C_{2-} RO-59	78.12	0.74	5.39	4.31	379.06
C_{3-} Bhima Shakti	79.37	0.73	5.48	4.42	387.95
SEm±	0.96	0.01	0.05	0.05	3.94
CD (P=0.05)	2.82	0.03	0.15	0.15	11.63
Zinc application					
Z_0 – Control	67.30	0.91	4.78	3.69	328.61
Z_1 – Soil application of zinc sulphate (25 kg ha^{-1})	78.34	0.73	5.38	4.33	375.71
Z_2 – Dipping of seedling in zinc solublizer @ 0.5%	71.24	0.80	5.08	4.00	357.60
Z_3 – Foliar spray of zinc sulphate @ 0.5%	79.68	0.72	5.50	4.42	386.67
SEm±	0.93	0.01	0.05	0.04	4.16
CD (P=0.05)	2.62	0.02	0.13	0.13	11.74

bulb yield (387.95 q ha^{-1}), net return (Rs 368680/ ha) and B:C ratio (3.83) over RO-01. However, this treatment remained statistically at par to RO-59 in given yield attributes and economics. Increase in average bulb weight, bulb diameter as well as bulb yield might be due to onion cultivars different morphological and biochemical characteristics that affect the biomass accumulation among different storage and vegetative parts. Average bulb weight within cultivars was due to their genetic variability. The increased vegetative growth of this cultivar resulted in higher fresh, dry weight and moisture content of bulb which plays a vital role in various metabolic processes. Primarily that results in increased net photosynthesis and helps in the translocation of photosynthates in storage organ of bulb resulting in increased weight of bulb. Thus, increased fresh weight of bulb due to humus substances could have mobilized the reserve food materials to the sink through increased activity of hydrolyzing and oxidizing enzymes. The increased net returns and benefit cost ratio directly correlated with the corresponding increase in the yield of onion due to different morphological and biochemical characteristics. Similar results have been reported by Gosai *et al.* (7) in onion and Sultana *et al.,* (19) in garlic.

Similarly, significant response of crop to the zinc application method in terms of average bulb weight (79.68 g), neck thickness (0.72 cm), equatorial diameter (5.50 cm), polar diameter (4.42 cm), total bulb yield (386.67 q ha^{-1}), net return (Rs 364973/ha) and B:C ratio (3.78) in case of foliar application is further supported by fact that the foliar spray of zinc sulphate quickly increases the uptake of nutrients in the organs and tissues of the onion which resulted in decrease of the nutritional deficiencies. The main function of zinc in plants is as a metal activator of several enzymes like dehydrogenase, proteinase and peptidases. The potent reasons responsible for superior performance of yield, yield attributes and economics might be due to supply of nutrients in available form. The increased growth parameters provided greater sites for photosynthesis and diversion of photosynthates towards sink (Khatemenla *et al.,* 9). The main function of zinc in plant is as a metal activator of several enzymes like dehydrogenase, proteinase and peptidases. Similar findings were recorded by Nubia *et al.* (13) and Ballabh *et al.* (3) in onion.

Table 3. Treatment wise benefit cost ratio of onion (Pooled mean of two years).

Treatments	Net returns (Rs ha^{-1})	Cost of cultivation	B:C ratio
Transplanting dates			
T_{1-} 10th December	307572	95816	3.21
T_{2-} 1st January	367963	95823	3.84
SEm±	4195	-	0.04
CD (P=0.05)	12374	-	0.12
Cultivars			
C_{1-} RO-1	285185	95700	2.98
C_{2-} RO-59	359438	95595	3.76
C_{3-} Bhima Shakti	368680	96261	3.83
SEm±	5137	-	0.05
CD (P=0.05)	15155	-	0.15
Zinc application			
Z_0 – Control	295625	94751	3.12
Z_1 – Soil application of zinc sulphate (25 kg/ha)	357465	96873	3.69
Z_2 – Dipping of seedling in zinc solublizer @ 0.5%	333008	95417	3.49
Z_3 – Foliar spray of zinc sulphate @0.5% at 30 & 45 DAT	364973	96553	3.78
SEm±	4486	-	0.05
CD (P=0.05)	12646	-	0.14

Interactive effect of transplanting dates and cultivars (Table 4) was found to have significant influence on overall improvement of yield, yield attributes and economics of onion. Significantly higher average bulb weight (87.92 g), neck thickness (0.65 cm), equatorial diameter (6.01 cm), polar diameter (4.96 cm), total bulb yield (423.21q ha^{-1}), net return (Rs 412230 ha^{-1}) and B:C ratio (4.28) were recorded in transplanting on 01st January and Bhima Shakti (T_2C_3) over rest of treatment combinations, except transplanting date 01st January and RO-59 (T_2C_2). The yield, yield attributes and economics enhancement under these treatments might be due to favourable environmental conditions particularly optimum temperature for seedling growth which helps to individual plants to utilize the climatic factors more efficiently. Temperature and photoperiod are the major ecological factors influencing onion growth and development in all phases (Mohamed, *et al.* 12). On the other hand, cultivars variation in their genetic make-up and differential behaviour under different climatic conditions (Ojha *et al*., 14). Onion cultivars may have different morphological and biochemical characteristics that affect the biomass accumulation among different storage and vegetative parts, as reported by Chandrakar *et al*. (4), Dwivedi *et al*. (6)

Similarly, interactive effect of transplanting dates and zinc was found to have significant influence on average bulb weight, bulb diameter, total bulb yield and economics (Table 5). Significantly higher average bulb weight (86 g), neck thickness (0.64 cm), equatorial diameter (6.03 cm), polar diameter (4.96 cm), total bulb yield (420.51 q^{-1}), net return (Rs 406729 /ha) and B:C ratio (4.21) were recorded in transplanting date 01st January and foliar application of zinc sulphate @0.5 per cent at 30 & 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).

Similarly, interactive effect of transplanting dates and zinc was found to have significant influence on average bulb weight, bulb diameter, total bulb yield and economics (Table 5). Significantly higher average bulb weight (86.00 g), neck thickness (0.64 cm), equatorial diameter (6.03 cm), polar diameter (4.96 cm), total bulb yield (420.51 q^{-1}), net return (Rs 406729 /ha) and B:C ratio (4.21) were recorded in transplanting date 01st January and foliar application of zinc sulphate @0.5 per cent at 30 & 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). The yield, yield attributes and better return of onion under these treatments might be due to favourable environmental conditions particularly optimum temperature for seedling growth which helped individual plants to utilize the climatic factors more efficiently. Temperature and photoperiod are the major ecological factors influencing onion growth and development in all phases. Similarly, as discussed earlier that application of zinc sulphate influenced the formation of some growth hormones in the plant as it is associated with water relation in the plants and also involved in auxins metabolism. Zinc sulphate also helps to accumulate more of photosynthates in plant to ensure significantly higher average bulb weight and diameter (Prusty *et al.,* 16).

The results of pooled analysis of two years revealed that transplanting under day temperature is 18-24°C, relative humidity 60-70 per cent and Bhima Shakti with foliar application of zinc sulphate (0.5%) at 30 & 45 DAT was found better for enhancing average bulb weight, bulb diameter and total bulb yield and reducing neck thickness of onion.

Table 4. Interactive effects of transplanting dates and cultivars on yield, yield attributes and economics of onion (Pooled mean of two years).

Treatments	C_1	C_2	C_3
	Average bulb weight (g)		
T_1	61.28	69.45	70.82
T_2	68.58	86.80	87.92
SEm±			1.35
CD (P=0.05)			3.99
	Neck thickness (cm)		
T_1	1.02	0.81	0.80
T_2	0.78	0.68	0.65
SEm±			0.01
CD (P=0.05)			0.04
	Equatorial diameter (cm)		
T_1	4.46	4.94	4.95
T_2	4.91	5.83	6.01
SEm±			0.07
CD (P=0.05)			0.21
	Polar diameter (cm)		
T_1	3.37	3.85	3.88
T_2	3.83	4.77	4.96
SEm±			0.07
CD (P=0.05)			0.21
	Total bulb yield (qha^{-1})		
T_1	306.58	351.37	352.66
T_2	332.28	406.79	423.21
SEm±			5.58
CD (P=0.05)			16.45
	Net returns (Rs ha^{-1})		
T_1	272611	324975	325131
T_2	297759	393901	412230
SEm±			7265
CD (P=0.05)			21433
	B:C ratio		
T_1	2.85	3.40	3.38
T_2	3.11	4.12	4.28
SEm±			0.07
CD (P=0.05)			0.21

C_{1-} RO-1; C_{2-} RO-59; C_{3-} Bhima Shakti, T_{1-} 10th December; T_{2-} 1st January

Table 5. Interactive effects of transplanting dates and zinc on yield, yield attributes and economics of onion (Pooled mean of two years).

Treatments	Z_0	Z_1	Z_2	Z_3
	Average bulb weight (g)			
T_1	56.49	73.43	65.46	73.36
T_2	78.11	83.26	77.02	86.00
SEm±				1.31
CD (P=0.05)				3.70
	Neck thickness (cm)			
T_1	1.03	0.81	0.87	0.79
T_2	0.78	0.66	0.73	0.64
SEm±				0.01
CD (P=0.05)				0.03
	Equatorial diameter (cm)			
T_1	4.53	4.93	4.72	4.96
T_2	5.02	5.85	5.45	6.03
SEm±				0.07
CD (P=0.05)				0.19
	Polar diameter (cm)			
T_1	3.43	3.85	3.63	3.89
T_2	3.95	4.81	4.37	4.96
SEm±				0.06
CD (P=0.05)				0.18
	Total bulb yield (q ha^{-1})			
T_1	318.48	346.62	329.56	352.84
T_2	338.73	404.81	385.64	420.51
SEm±				5.89
CD (P=0.05)				16.60
	Net returns (Rs ha^{-1})			
T_1	281143	325203	300727	323216
T_2	310108	389727	365289	406729
SEm±				6344
CD (P=0.05)				17885
	B:C ratio			
T_1	2.97	3.36	3.15	3.35
T_2	3.27	4.03	3.83	4.21
SEm±				0.07
CD (P=0.05)				0.19

Z_0 – Control; Z_1 – Soil application of $ZnSo_4$ (25 kg/ha); Z_2 – Dipping of seedling in zinc solublizer @ 0.5% before transplanting; Z_3 – Foliar spray of $ZnSo_4$ @0.5% at 30 & 45 DAT, T_{1-} 10th December; T_{2-} 1st January

AUTHORS' CONTRIBUTION

Conceptualization of research (CG, BLM, GOP); Designing of experiments (CMR, CG and BLN); contribution of experimental materials (KPK, SAK and NM); field/lab experiments and data collection (CG, KPK, NM and BLN); data interpretation (CG, CMR, GOP and BLM) and preparation of the manuscript (CG, GOP, BLN and SAK).

DECLARATION

The authors declare that we do not have any conflict of interest.

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