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Effect of water regimes, plot configuration and mulching on growth and economics of onion (*Allium cepa* L.)

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Abstract

The experiment was carried out during *rabi* season 2020-21 and 2021-22 at Instructional farm, Department of Horticulture, AU, Jodhpur to study the effect of water regimes, plot configuration and mulching on growth and economics of onion (*Allium cepa* L.). The experiment was laid out in Split-Split Plot Design with three replications. Three factors were studied in this experiment: Main factor A), water regimes included three levels (I1-1.0 IW/CPE, I2-0.8 IW/CPE and I3-0.6 IW/CPE ratio) and two sub factors A) land configuration include two levels (B1- Flat bed configuration and B2- Raised bed configuration), and B) Mulching include four levels (M1- No-mulch, M2- Black mulch, M3- Silver-black mulch and M4- White-black mulch). The results showed that the maximum number of leaves per plant, neck diameter, bolting percent, net returns and B:C ratio were recorded under 1.0 IW/CPE, raised bed configuration and black mulch. The earliest maturity was recorded under 0.6 IW/CPE, flat bed configuration and no mulch.

Key words: B:C ratio, bolting percent, plot configurations, neck diameter, water regimes

Introduction

Onion is grown in India in an area of 1.62 million hectare with a production of 26.64 million tonnes (Anonymous, 2022). In India, Maharashtra is the leading onion producing state in terms of area as well as production. Maharashtra is occupying an area of 0.70 million hectares with a total production of 10.48 million tonnes. Onion is cultivated as an annual crop for bulb production and as a biennial crop for seed production. The edible portion of onion is a bulb which develops underground as modified leaves. Both immature and mature bulbs are used as vegetables and condiments. Onion is a short duration and quick growing herb having various uses such as vegetable, spice and medicine. It is an integral part of Indian diet and used in a variety of foods. It can be eaten raw as salad as well as fried, boiled or roasted, flavoring soups, canned food products and preparation of different dishes (Gambo *et al.,* 2008).

Western Rajasthan has very limited water resources due to low rainfall and brackish ground water. Therefore, scanty availability of irrigation water in the region is one of the major limitations in cultivation of horticultural crops. "Per Drop More Crop" is very important micro-irrigation component of the Pradhan Mantri Krishi Sinchayee Yojna (PMKSY-PDMC), primarily focusing on better use of irrigation water with higher water use efficiency. Hence, saving of every drop of water is need of the hour for successful crop cultivation and bringing more areas under irrigated crop cultivation. Mermoud *et al.* (2005) reported that increase in frequency of irrigation enhanced the growth, bulb development, crop water availability and yield of onion.

The raised bed planting improved the water use efficiency, crop production, utilization of sunlight, and soil physiochemical properties and also lesser crop-weed competition in garlic (Kumar *et al.*, 2015). The different types of mulches like transparent mulching, black mulching, saw dust, water hyacinth and rice straw helped in better utilization of the soil nutrients and conserved the soil moisture efficiently in bulbous crops (Jamil *et al.*, 2005; Anisuzzaman *et al.*, 2009; Islam *et al.*, 2010 and Inusah *et al.*, 2013).

Material and Method

The experiment was conducted during *rabi* seasons of 2020–2021 and 2021–2022 at the instructional farm, College of Agriculture, Jodhpur, situated at an altitude of 231 m above mean sea level at $26^0$36" North latitude and $73^0$04" east longitude. The region falls under agro-climatic zone IA (Arid Western Plains Zone) of Rajasthan. There were three factors studied in this experiment one major factor *viz.*, A) Water regimes included three levels (I1-1.0 IW/CPE, I2-0.8 IW/CPE and I3-0.6 IW/CPE ratio) and two sub factors *viz.*, A) Land configuration included two levels (B1- Flat bed configuration and B2- Raised bed configuration), and B) Mulching included four levels (M1- No mulch, M2- Black mulch, M3- Silver black mulch and M4- White black mulch). The analytical results revealed that the experimental field soil was sandy loam in texture, slightly alkaline in reaction, poor in organic carbon (0.14 % and 0.13 %), low in available N (174.0 kg/ha and 171.0 kg/ha), medium in available P (22.2 kg/ha and 22.0 kg/ha) and high in available K (325.0 kg/ha and 319.0 kg/ha) during 2020-21 and 2021-22, respectively. The number of leaves per plant, neck diameter, bolting percent, net returns and B:C ratio were determined to find out the effect of water regimes, plot configuration and mulching.

Results

The number of leaves per plant, neck diameter, time taken to maturity and bolting differed significantly due to different water regimes in 2020-21, 2021- 22 and pooled data (Table 1 and 2). The maximum number of leaves per plant (14.18, 13.79 and 13.99,

respectively), neck diameter (23.07 mm, 21.91 mm and 22.49 mm, respectively), time taken to maturity (118.40 days, 115.36 days and 116.88 days, respectively) and bolting (1.85 %, 1.91 % and 1.88 %, respectively) were recorded under the treatment 1.0 IW/CPE (I_1) which was statistically at par with the treatment 0.8 IW/CPE (I_2). The minimum number of leaves per plant (11.62, 11.19 and 11.41, respectively), neck diameter (18.36 mm, 17.47 mm and 17.92 mm, respectively), time taken to maturity (103.63 days, 100.78 days and 102.20 days, respectively) and bolting (1.01 %, 1.13 % and 1.07 %, respectively) were recorded under the treatment 0.6 IW/CPE (I_3) during the study.

Land configurations had significant effect on growth attributes in 2020-21, 2021-22 and pooled data analysis. Raised bed configuration (B_2) recorded significantly higher number of leaves per plant (13.70, 13.27 and 13.49, respectively), neck diameter (22.64 mm, 21.44 mm and 22.04 mm, respectively), time taken to maturity (116.51 days, 115.30 days and 115.91 days, respectively) and bolting (1.70 %, 1.74 % and 1.72 %, respectively) as compared to flat bed configuration (B_1) recording number of leaves per plant (12.57, 12.08 and 12.32, respectively), neck diameter (19.57 mm, 18.61 mm and 19.09 mm, respectively), time taken to maturity (108.59 days, 104.73 days and 106.66 days, respectively) and bolting (1.32%, 1.43% and 1.37%, respectively).

There were significant effects of different types of mulching on growth attributes in 2020-21, 2021-22 and pooled analysis. The maximum number of leaves per plant (13.95, 13.63 and 13.79, respectively), neck diameter (22.84 mm, 21.47 mm and 22.15 mm, respectively), time taken to maturity (117.39 days, 115.33 days and 116.36 days, respectively) and bolting (1.82 %, 1.90 % and 1.86 %, respectively) were observed with the treatment black mulch (M_2) which was at par with the treatment silver-black mulch (M_3). Whereas the minimum number of leaves per plant (12.00, 11.42 and 11.71, respectively), neck diameter (18.75 mm, 18.08 mm and 18.41 mm, respectively), time taken to maturity

Table 1. Effect of water regimes, plot configuration and mulching on number of leaves per plant and neck diameter of onion

Treatments	Number of leaves per plant			Neck diameter (mm)		
	2021	2022	Pooled	2021	2022	Pooled
Water regimes levels						
I_1	14.18	13.79	13.99	23.07	21.91	22.49
I_2	13.60	13.04	13.32	21.88	20.69	21.28
I_3	11.62	11.19	11.41	18.36	17.47	17.92
SEm±	0.34	0.38	0.26	0.68	0.68	0.48
CD. @5%	1.34	1.50	0.84	2.68	2.69	1.58
Bed levels						
B_1	12.57	12.08	12.32	19.57	18.61	19.09
B_2	13.70	13.27	13.49	22.64	21.44	22.04
SEm±	0.18	0.24	0.15	0.33	0.45	0.28
CD. @5%	0.62	0.85	0.47	1.14	1.56	0.86
Mulch levels						
M_1	12.00	11.42	11.71	18.75	18.08	18.41
M_2	13.95	13.63	13.79	22.84	21.47	22.15
M_3	13.49	12.99	13.24	21.85	20.68	21.26
M_4	13.09	12.66	12.88	20.99	19.87	20.43
SEm±	0.25	0.33	0.20	0.42	0.49	0.32
CD. @5%	0.71	0.93	0.58	1.20	1.41	0.91

I_1-1.0 IW/CPE, I_2-0.8 IW/CPE, I_3-0.6 IW/CPE, B_1-Flat bed, B_2-Raised bed, M_1-No-mulch (control), M_2-Black mulch, M_3-Silver-black mulch and M_4-White-black mulch

Table 2. Effect of water regimes, plot configuration and mulching on time taken for maturity and bolting percent of onion

Treatments	Maturity (days)			Bolting (%)		
	2020-21	2021- 22	Pooled	2020-21	2021-22	Pooled
Water regimes						
I_1	118.40	115.36	116.88	1.85	1.91	1.88
I_2	115.64	113.90	114.77	1.66	1.70	1.68
I_3	103.63	100.78	102.20	1.01	1.13	1.07
SEm±	1.43	1.97	1.22	0.10	0.13	0.08
CD @5%	5.61	7.72	3.96	0.40	0.49	0.26
Land configurations						
B_1	108.59	104.73	106.66	1.32	1.43	1.37
B_2	116.51	115.30	115.91	1.70	1.74	1.72
SEm±	1.16	1.57	0.97	0.09	0.08	0.06
CD @5%	4.01	5.42	3.00	0.30	0.27	0.18
Mulching						
M_1	104.31	103.19	103.75	1.06	1.18	1.12
M_2	117.39	115.33	116.36	1.82	1.90	1.86
M_3	115.14	111.52	113.33	1.66	1.69	1.68
M_4	113.38	110.02	111.70	1.48	1.55	1.52
SEm±	1.35	1.78	1.12	0.11	0.11	0.08
CD @5%	3.88	5.11	3.15	0.31	0.32	0.22

I_1-1.0 IW/CPE, I_2-0.8 IW/CPE, I_3-0.6 IW/CPE, B_1-Flat bed, B_2-Raised bed, M_1-No-mulch (control), M_2-Black mulch, M_3-Silver-black mulch and M_4-White-black mulch

(104.31 days and 103.19 days 103.75 days, respectively) and bolting (1.06 %, 1.18 % and 1.12 %, respectively) were observed with the treatment of no mulch (M_1).

The net returns and B:C ratio differed significantly due to different water regimes during 2020-21, 2021-22 and pooled data (Table 3). The maximum net returns (3,94,597 Rs/ha, 3,76,741 Rs/ha and 3,85,659 Rs/ha in 2020-21, 2021-22 and pooled data, respectively) and B:C ratio (3.68, 3.48 and 3.58, respectively) were recorded in 1.0 IW/CPE (I_1) which was at par with 0.8 IW/CPE (I_2), while the minimum net returns (2,67,654 Rs/ha, 2,51,605 Rs/ha and 2,59,630 Rs/ha in 2020-21, 2021-22 and pooled data, respectively) and B:C ratio (2.83, 2.67 and 2.75, respectively) were recorded in 0.6 IW/CPE (I_3).

The data revealed that the raised bed configuration (B_2) recorded higher net returns (3,71,517 Rs/ha, 3,54,090 Rs/ha, 3,62,804 Rs/ha in 2020-21, 2021-22 and the pooled analysis, respectively) and B:C ratio (3.52, 3.33 and 3.43, respectively) as compared to flat bed configuration (B_1) with lower net returns(3,09,960 Rs/ha, 2,93,743 Rs/ha and 3,01,851 Rs/ha in 2020-21, 2021-22 and the pooled analysis, respectively) and B:C ratio (3.12, 2.95 and 3.03, respectively).

The net returns and B:C ratio in onion were significantly affected by various types of mulching during the study. The maximum net returns (3,74,133 Rs/ha, 3,60,449 Rs/ha and 3,67,291 Rs/ha in 2020-21, 2021-22 and pooled data, respectively) and B:C ratio (3.53, 3.37 and 3.45, respectively) were obtained with the treatment black mulch (M_2) which was at par with the treatment silver-black mulch (M_3). The minimum net returns (2,91,162 Rs/ha, 2,67,930 Rs/ha and 2,79,546 Rs/ha in 2020-21, 2021-22 and pooled data, respectively) and B:C ratio (3.03, 2.81 and 2.92, respectively) were obtained with the no mulch (M_1).

Table 3. Effect of water regimes, plot configuration and mulching on net returns and B:C ratio of onion

Treatments	Net returns (Rs/ha)			B:C ratio		
	2021	2022	Pooled	2021	2022	Pooled
Water regimes levels (I)						
I_1	3,94,597	3,76,741	3,85,669	3.68	3.48	3.58
I_2	3,59,965	3,43,403	3,51,684	3.45	3.27	3.36
I_3	2,67,654	2,51,605	2,59,630	2.83	2.67	2.75
SEm±	16557.95	21159.90	13434.16	0.11	0.14	0.09
CD. @5%	65014.57	83084.04	43811.25	0.44	0.55	0.29
Bed levels (B)						
B_1	3,09,960	2,93,743	3,01,851	3.12	2.95	3.03
B_2	3,71,517	3,54,090	3,62,804	3.52	3.33	3.43
SEm±	6870.36	7517.07	5091.86	0.05	0.05	0.03
CD. @5%	23774.58	26012.49	15689.58	0.16	0.17	0.11
Mulch levels (M)						
M_1	2,91,162	2,67,930	2,79,546	3.03	2.81	2.92
M_2	3,74,133	3,60,449	3,67,291	3.53	3.37	3.45
M_3	3,59,003	3,42,090	3,50,547	3.43	3.25	3.34
M_4	3,38,656	3,25,196	3,31,926	3.29	3.13	3.21
SEm±	9276.24	10502.20	7006.15	0.06	0.07	0.05
CD. @5%	26605.71	30121.98	19751.63	0.18	0.20	0.13

Discussion

The significant enhancement in the studied growth attributes in 1.0 IW/CPE (I_1) treatment might be due to better availability of moisture and nutrients resulting in increased rate of photosynthesis which might have favoured the plant growth. Similarly, Leilah (2009) reported the role of water in increasing the uptake of mineral elements from soil and translocation of photosynthetic assimilates, thus reflected increases in number of leaves per plant in onion. Similar results were found by Guluma (2009) reported that increased frequency and amount of water application promoted vegetative growth and delayed the development period in tomato. Sarkar *et al.* (2008) reported that the higher number of leaves per plant and neck thickness was recorded with 100 % PE as compared to 50% PE in garlic. Moreover, Metwally (2011) recorded the higher number of leaves per plant, neck diameter and bolters plant with higher water supply as compared to lower water supply in onion. Lodhi *et al.* (2014) reported that the minimum number of days to flowering, fruit initiation and fruit maturity were observed with low irrigation level in sweet pepper. Gethe (2002) recorded higher bolting percent in onion with higher frequency of irrigation.

The improved plant growth under raised bed configuration could be attributed to the fact that the raised bed configurations enhanced nutrient uptake with the improved soil pulverization and aeration, resulting in increased plant growth parameters. Kaur (2022) reported that the loose soil and favourable soil moisture, higher soil temperatures number of leaves per plant was recorded in the raised bed configuration compared to the flat bed configuration in garlic. According to Kadari *et al* (2019), the raised bed proved to be significantly better than the flat bed in onion. The number of leaves per plant and neck thickness increased in the raised bed configuration probably due to the availability of adequate nutrients and favourable growing conditions. Salari *et al.* (2021) reported the minimum time taken to maturity was recorded in flat bed configuration as compared to raised bed configuration in onion.

The positive effect of black mulch (M_2) on plant vegetative growth might be due to better water conservation and increase in soil temperature during the cool season of vegetative growth. Rachel *et al.* (2018) reported improved plant growth under black polythene mulch due to high moisture availability as compared to other mulches which also helped in increased plant nutrient uptake (NPK) and number of leaves per plant whereas, comparatively poor plant growth was reported under no mulch conditions due to lower soil moisture hampering plant growth and development in onion. Anisuzzaman *et al.* (2009) recorded higher number of leaves per plant and length of scape under black mulch as compared to no mulch in onion.

The maximum net returns and B:C ratio obtained under 1.0 IW/CPE (I_1) which was at par with 0.8 IW/CPE (I_2) were directly correlated with the maximum bulb yield. Chauhan (2017) reported that the net returns and B : C ratio increased sharply from 50 to 125% of pan evaporation replenishment due to a sharp increase in bulb yield of onion as well as the gross return. The recorded results are similar to the past findings of Silabut *et al.* (2014) and Gyanendra *et al.* (2016) in garlic and Tripathi *et al.* (2010) in onion.

The higher net returns and B:C ratio recorded under the raised bed configuration (B_2) were directly correlated with higher bulb yield under the raised bed configuration (B_2), which might be due to improved soil aeration and water use efficiency under the raised bed configuration (B_2) as compared to the flatbed configuration (B_1). Sarker *et al.* (2017) obtained higher net returns and B:C ratio in onion cultivation under the raised bed configuration due to the improved water use efficiency and better soil aeration and drainage as compared to the flatbed configuration. The results are in accordance with the findings of Gethe (2002) in onion.

The maximum net returns and B:C ratio obtained under black mulch (M_2) could be attributed to the maximum bulb yield. Singh *et al.* (2009) obtained the maximum net returns and B:C ratio with polyethylene mulching when tomato was cultivated with drip irrigation at 80% ET. The obtained results resemble the findings of Palada (2000) in basil and Anjitha Krishna *et al.* (2021) in onion.

Based on the present research findings, it may be concluded that onion cultivation under arid condition of Western Rajasthan during *rabi* season with 0.8 IW/CPE irrigation level (which was found to be at par with 1.0 IW/CPE), raised bed plot configurations and black mulch was successfully attempted with the improved growth and economics of onion. As per the pooled analysis, the maximum number of leaves per plant, neck diameter, bolting percent, net returns and B:C ratio were obtained with 1.0 IW/CPE (which was at par with 0.8 IW/CPE), raised bed plot configurations and black mulch. While earliest maturity was found under 0.6 IW/CPE, flat bed configuration and no mulch.

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