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Quality and Nutrient Uptake of Onion *(Allium cepa* L.) as Influenced by Water Regimes, Land Configurations and Mulching

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ABSTRACT

Background: Scanty availability of irrigation water in the region is one of the major limitations in cultivation of horticultural crops. Land configurations and plastic mulching has been found to be an effective technique for increasing the profitability of bulb crops. The objective of this study was to find the effect of water regimes, land configuration and mulching on growth, yield and water use efficiency of onion (*Allium cepa* L.) under the soil and agro climatic conditions of Western Rajasthan.

Methods: The experiment was conducted at Instructional farm, Department of Horticulture, AU, Jodhpur during *rabi* season of 2020-21 and 2021-22. There were three factors studied in this experiment one major factor *viz*., A) Water regimes include 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 include two levels (B_1- Flat bed configuration and B_2- Raised bed configuration) and B) Mulching include four levels (M_1- No-mulch, M_2- Black mulch, M_3- Silver-black mulch and M_4- White-black mulch). Overall there were twenty four treatment combinations.

Result: On the basis of pooled analysis, the dry matter content, double bulb, leaf chlorophyll content, NPK and S content were significantly affected by different water regimes, land configurations and mulch types.

Key words: *Allium cepa*, Double bulb, Leaf chlorophyll content, Mulching, Water regimes.

INTRODUCTION

Vegetables are vital sources of proteins, minerals, vitamins, micronutrients, dietary fibre, antioxidants, phytochemicals, *etc*. in our daily diet. They also contain anti-carcinogenic principles and ensure nutritional security and economic *via*bility. More than 60 kinds of vegetables are grown all over India. India stands first in ginger and okra production and second in production of onion, potato, cabbage, brinjal, cauliflower, *etc*., having total area of 10.86 million hectares under vegetables cultivation with total production of 200.44 million tonnes (Anonymous, 2022).

Onion can be grown under a wide range of climatic conditions, but mild conditions without excess heat, cold and excess rainfall are best suited. It requires a temperature of 15-25°C before bulbing and 15.6-21°C for bulb formation. Onion is very sensitive to moisture stress because of its shallow root system. Onion is rich in nutrients, vitamins and minerals. Onion bulb contains carbohydrates (11.0 g), fiber (0.6 g), moisture (86.8 g) proteins (1.2 g) and several vitamins like vitamin A (0.012 mg), thiamine (0.08 mg), riboflavin (0.01 mg), vitamin C (11 mg) and niacin (0.2 mg) and some minerals like calcium (27 mg), phosphorus (39 mg), potassium (157 mg), sodium (1.0 mg) and iron (0.7 mg) (Suresh, 2007).

Under such circumstances, drip irrigation is an effective technology by which limited water is applied at low pressure near the root zone of the plant for enhancing the water use efficiency and increasing production with limited water availability (Kusçu *et al*., 2009, Shock, 2013 and Enciso *et al*., 2015). Mermoud *et al*. (2005) reported that increase in frequency of irrigation enhanced the growth, bulb development, crop water availability and yield of onion. Kadayifci *et al*. (2005) observed that onion bulb yield and dry matter content were highly correlated with appropriate water supply. Similarly, Bekele and Tilahun (2007) observed that adequate irrigation significantly increased the yield as compared to deficit irrigation but the water use efficiency increased under the deficit irrigation in onion.

Hossain *et al*. (2010a) reported that the raised bed configuration improved onion production and also affirmed that it can save irrigation water, reduce planting costs and

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labour requirements. Mahajan *et al*. (2007) observed reduced weed infestation, decreased loss of soil water through evaporation thus reduced irrigation requirements, enhanced root development and crop development and earlier harvest of crop with the use of mulching. Parsottambhai *et al*. (2020) reported that plastic mulching enhanced establishment of seedlings, plant growth, yield and quality of onion and also benefited as better diurnal pattern of soil temperature and canopy air temperature.

MATERIALS AND METHODS

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°36" North latitude and 73°04" east longitude. The region falls under Agro-Climatic Zone IA (Arid Western Plains Zone) of Rajasthan. The experiment was laid out in Split-Split Plot Design with three replications. The data pertaining to details of treatment used in the study are presented in Table 1. There were three factors studied in this experiment one major factor viz., Water regimes including three levels (I_1-1.0 IW/CPE, I2-0.8 IW/CPE and I3-0.6 IW/CPE ratio) and two sub factors *viz*., A) Land configurations including two levels (B_1- Flat bed configuration and B_2- Raised bed configuration) and B) Mulching including four levels (M_1- No mulch, M_2- Black mulch, M_3- Silver black mulch and M_4- 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 quality parameters of onion bulb observed during the study included the dry matter content, double bulb, leaf chlorophyll content, NPK and S content in onion leaf. The double bulb percent was calculated by counting the number of double bulbs among the harvested bulbs in each treatment sub-plot.

The amount of chlorophyll in the leaf was calculated by weighing out one gram of fresh leaf sample, adding five milliliters of water and homogenizing it in a blender. In order to extract the pigments, 4.5 ml of 80% acetone was added to the homogenate after it had been diluted to a volume of 10 ml with water. Its optical density (O.D.) was measured at 480, 645 and 663 nm using 80% acetone as a blank after centrifugation and the removal of the supernatant. The following formulae were used to compute the total amount of chlorophyll, chlorophyll a and chlorophyll b (Rangana, 2007):

Total chlorophyll (g lit) = (0.0202) (O.D at 645) + (0.00802) (O.D at 663) Chlorophyll a (g lit) = (0.0127) (O.D at 663) - (0.00269) (O.D at 645) Chlorophyll b (g lit) = (0.0229) (O.D at 645) - (0.00480) (O.D at 663)

Where,

$O.D_{645}$ = Optical density at a wavelength of 645.

$O.D_{663}$ = Optical density at a wavelength of 663.

Nitrogen content in leaves was determined by automatic micro distillation system-kjeldhal s method as given by Singh and Praharaj (2017). Phosphorus content in leaves was determined by vanadomolybdate yellow colour method as given by Jackson (1967). Sulphur content in onion leaves was determined by spectrophotometer by di-acid extract method given by Bardsley and Lancaster (1960). Potassium content in leaves was determined by flame photometer by di-acid extract method given by Jackson (1967).

RESULTS AND DISCUSSION

The data on quality and nutrient of onion as influenced by water regimes, land configurations and different mulches are presented in Table 2 and Table 3. The maximum dry matter content (18.59%, 17.76% and 18.17% in 2020-21, 2021-22 and pooled analysis, respectively) and double bulb (2.27%, 2.05% and 2.16%, respectively) were recorded in 1.0 IW/CPE (I_1) which was statistically at par with 0.8 IW/CPE (I_2). The minimum dry matter content (15.59%, 14.72% and 15.15% in 2020-21, 2021-22 and pooled analysis, respectively) and double bulb (1.39%, 1.19% and 1.29%, respectively) were recorded in 0.6 IW/CPE (I3). The highest dry matter content recorded under 1.0 IW/CPE (I_1) might be due to better nutrient uptake and soil moisture availability leading to increased photosynthetic rate and greater translocation and accumulation of carbohydrates. Ramada and Ramanathan (2017) reported that the water deficit in onions at any stage of growth lead to a reduction in dry matter yield; potentially as a result of restrictions in assimilate production and accumulation in onions under stress conditions. The increased number of double bulbs in 1.0 IW/CPE (I_1) could be attributed to sufficient moisture availability, facilitating higher cell division and activation of several growth centers in the bulb's basal plate, leading to increased bulb doubling in onion. Metwally (2011) also recorded higher double bulb with higher water supply as compared to lower water supply in onion.

The raised bed configuration (B_2) was recorded higher dry matter content (18.10%, 17.09% and 17.59% in 2020-21, 2021-22 and the pooled analysis, respectively) and double

Table 1: Details of treatments used in the study.

Treatments	Symbols
Main factor	
1.0 IW/CPE through drip irrigation	I_1
0.8 IW/CPE through drip irrigation	I_2
0.6 IW/CPE through drip irrigation	I_3
Sub factor	
Flat bed	B_1
Raised bed	B_2
Sub factor	
No mulch (control)	M_1
Black mulch	M_2
Silver-black mulch	M_3
White-black mulch	M_4

bulbs (2.12%, 1.95% and 2.03%, respectively), whereas the flat bed configuration (B_1) was recorded lower dry matter content (16.47%, 15.91% and 16.19% in 2020-21, 2021-22 and the pooled analysis, respectively) and double bulbs (1.63%, 1.44% and 1.54%, respectively). The increase in dry matter content of onion bulbs produced under the raised bed configuration (B_2) might be due to better soil aeration; friability of soil and better root growth, resulting in enhanced uptake of nutrients and better translocation of assimilates from source to sink, ultimately leading to higher dry matter accumulation in onion bulbs. The obtained results are consistent with the finding of Chadrakant (2021) in onion. The increased number of double bulbs under raised bed configuration (B_2) might be due to better soil aeration and friability of soil, enhancing the bulb growth with higher cell division and activation of several growth centers at the basal plate of bulb, leading to increased doubling of bulbs.

The dry matter content and double bulbs were significantly affected due to various types of mulching during 2020-21, 2021-22 and the pooled analysis. The maximum dry matter content (18.42%, 17.46% and 17.94% during 2020-21, 2021-22 and the pooled analysis, respectively) and double bulbs (2.15%, 2.01% and 2.08%, respectively) were recorded in black mulch (M_2) which was statistically at par with silver-black mulch (M_3), whereas the minimum dry matter content (15.99%, 15.27% and 15.63% in 2020-21, 2021-22 and the pooled analysis, respectively) and double bulbs (1.55%, 1.26% and 1.41%, respectively) were recorded in no mulch (M_1). The highest dry matter content of onion bulbs noted under black mulch (M_1) might be due to congenial soil temperature in winter season due to trapping of heat as compared to bare soil surface in control, promoting higher physiology activity of roots leading to better nutrient and water uptake which improved the assimilation of photosynthates and their translocation to the sink, ultimately resulting in enhanced dry matter content of the bulbs. The obtained results are supported by Parsottambhai (2020) and Rahman *et al.* (2001) in onion. The highest double bulbs produced under black mulch (M_2) could be attributed to raise soil temperature due to more heat trapping under the black polythene mulch which could have activated formation of multiple growth centers in the basal plate of the bulb, ultimately increasing the number of double bulbs.

The leaf chlorophyll content, leaf N content, leaf P content, leaf K content and leaf S content differed significantly due to different water regimes in 2020-21, 2021- 22 and pooled data. The maximum leaf chlorophyll content (20.43 µg/100 g, 19.66 µg/100 g and 20.04 µg/100 g respectively), leaf N content (180.92 mg/100 g, 177.41 mg/100 g and 179.17 mg 100 g, respectively), leaf P content (44.47 mg/100 g, 43.22 mg/100 g and 43.84 mg/100 g, respectively), leaf K content (232.82 mg/100 g, 231.31 mg/100 g and 232.07 mg/100 g, respectively) and leaf S content (0.46%, 0.45% and 0.45%, 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 leaf chlorophyll content (17.43 µg/100 g, 16.93 µg/100 g and 17.18 µg/100 g,

Table 2: Effect of water regimes, land configurations and mulching on dry matter content, double bulb and Leaf chlorophyll content (µg/100 g) of onion.

Treatments	Dry matter content (%)			Double bulb (%)			Leaf chlorophyll content (µg/100 g)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Water regimes									
I_1	18.59	17.76	18.17	2.27	2.05	2.16	20.43	19.66	20.04
I_2	17.67	17.02	17.35	1.97	1.84	1.90	19.32	19.18	19.25
I_3	15.59	14.72	15.15	1.39	1.19	1.29	17.43	16.93	17.18
SEm±	0.48	0.48	0.34	0.11	0.13	0.09	0.32	0.38	0.25
CD @5%	1.88	1.89	1.11	0.43	0.52	0.28	1.27	1.51	0.82
Land configurations									
B_1	16.47	15.91	16.19	1.63	1.44	1.54	18.08	17.85	17.97
B_2	18.10	17.09	17.59	2.12	1.95	2.03	20.04	19.32	19.68
SEm±	0.25	0.29	0.19	0.08	0.10	0.07	0.24	0.23	0.17
CD @5%	0.86	1.01	0.59	0.28	0.36	0.20	0.83	0.81	0.52
Mulching									
M_1	15.99	15.27	15.63	1.55	1.26	1.41	17.81	17.34	17.58
M_2	18.42	17.46	17.94	2.15	2.01	2.08	20.13	19.48	19.80
M_3	17.65	16.86	17.26	1.96	1.84	1.90	19.30	19.16	19.23
M_4	17.07	16.40	16.73	1.85	1.66	1.76	19.00	18.38	18.69
SEm±	0.35	0.36	0.25	0.09	0.12	0.07	0.30	0.33	0.22
CD @5%	0.99	1.04	0.71	0.25	0.33	0.20	0.86	0.94	0.63

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.

respectively), leaf N content (160.72 mg/100 g, 158.49 mg/100 g and 159.60 mg/100 g, respectively), leaf P content (38.35 mg/100 g, 36.64 mg/100 g and 37.49 mg/100 g, respectively), leaf K content (207.54 mg/100 g, 205.23 mg/100 g and 206.39 mg/100 g, respectively) and leaf S content (0.37% , 0.35% and 0.36%, respectively) were recorded under the treatment 0.6 IW/CPE (I3) during the study.

The significant enhancement in the studied nutrient contents of 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. The findings are in agreement with Kemal (2013) in shallot and Gebregwergis *et al*. (2015) in onion. 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 nutrient content of onion. Jeelani *et al*. (2017) recorded higher leaf chlorophyll content and NPK uptake with higher irrigation level as compared to lower irrigation level in broccoli.

Land configurations had significant effect on nutrient contents of onion in 2020-21, 2021-22 and pooled data analysis. Raised bed configuration (B_2) recorded significantly higher leaf chlorophyll content (20.04 µg/100 g, 19.32 µg/100 g and 19.68 µg/100 g, respectively), leaf N content (176.93 mg/100 g, 174.00 mg/100 g and 175.46 mg/100 g, respectively), leaf P content (43.38 mg/100 g, 42.07 mg/100 g and 42.73 mg/100 g, respectively), leaf K content (227.92 mg/100 g, 225.64 mg/100g and 226.78 mg/100 g, respectively) and leaf S content (0.45%, 0.43% and 0.44%, respectively) as compared to flat bed configuration (B_1) recording leaf chlorophyll content (18.08 µg/100 g, 17.85 µg/100 g and 17.97 µg/100 g, respectively), leaf N content (167.03 mg/100 g, 165.31 mg/100 g and 166.17 mg/100 g, respectively), leaf P content (40.55 mg/100 g, 38.56 mg/100 g and 39.56 mg/100 g, respectively), leaf K content (215.93 mg/100 g, 214.50 mg/100 g and 214.21 mg/100 g, respectively) and leaf S content (0.40%, 0.39% and 0.39%, respectively).

The improved nutrient uptake 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 nutrient content of onion. Das *et al*. (2020) recorded higher nitrogen, phosphorus and potassium uptake under raised bed method as compared to flat bed method in ginger. The observed results are in agreement with those of Dodake (2005) in onion.

There were significant effects of different types of mulching on leaf chlorophyll content, N, P, K and sulphur content in 2020-21, 2021-22 and pooled analysis. The maximum leaf chlorophyll content (20.13 µg/100 g, 19.48 µg/100 g and 19.80 µg/100 g, respectively), leaf N content (179.16 mg/100 g, 176.41 mg/100 g and 177.78 mg/100 g, respectively), leaf P content (43.95 mg/100 g, 42.39 mg/100 g and 43.17 mg/100 g, respectively), leaf K content (230.10 mg/100 g, 229.03 mg/100 g and 229.56 mg/100 g, respectively) and leaf S content (0.45%, 0.44% and 0.44%, respectively) were observed with the treatment black mulch (M_2) which was at par with the treatment silver-black mulch (M_3). Whereas

Table 3: Effect of water regimes, land configurations and mulching on NPK and S content of onion.

Treatments	N content (mg/100 g)			P content (mg/100 g)			K content (mg/100 g)			S content (%)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
Water regimes												
I_1	180.92	177.41	179.17	44.47	43.22	43.84	232.82	231.31	232.07	0.46	0.45	0.45
I_2	174.30	173.06	173.68	43.10	41.08	42.09	225.41	223.67	224.54	0.44	0.43	0.44
I_3	160.72	158.49	159.60	38.35	36.64	37.49	207.54	205.23	206.39	0.37	0.35	0.36
SEm±	2.36	2.52	1.72	0.86	0.96	0.64	3.30	3.33	2.34	0.01	0.01	0.01
CD @5%	9.25	9.88	5.62	3.37	3.77	2.10	12.97	13.06	7.64	0.03	0.05	0.02
Land configurations												
B_1	167.03	165.31	166.17	40.55	38.56	39.56	215.93	214.50	215.21	0.40	0.39	0.39
B_2	176.93	174.00	175.46	43.38	42.07	42.73	227.92	225.64	226.78	0.45	0.43	0.44
SEm±	1.86	1.93	1.34	0.54	0.64	0.42	2.41	2.46	1.72	0.01	0.01	0.00
CD @5%	6.44	6.68	4.13	1.88	2.22	1.30	8.33	8.51	5.30	0.02	0.03	0.01
Mulching												
M_1	17.81	17.34	17.58	162.68	160.00	161.34	211.09	207.94	209.52	0.39	0.37	0.38
M_2	20.13	19.48	19.80	179.16	176.41	177.78	230.10	229.03	229.56	0.45	0.44	0.44
M_3	19.30	19.16	19.23	174.23	172.59	173.41	224.79	223.04	223.92	0.44	0.42	0.43
M_4	19.00	18.38	18.69	171.86	169.61	170.73	221.72	220.27	221.00	0.42	0.41	0.41
SEm±	0.30	0.33	0.22	2.15	2.33	1.58	2.88	3.01	2.08	0.01	0.01	0.01
CD @5%	0.86	0.94	0.63	6.16	6.68	4.47	8.27	8.62	5.87	0.02	0.03	0.02

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.

the minimum leaf chlorophyll content (17.81 µg/100g, 17.34 µg/100 g and 17.58 µg/100 g, respectively), leaf N content (162.68 mg/100 g, 160.00 mg/100 g and 161.34 mg/100 g, respectively), leaf P content (39.38 mg/100 g, 37.78 mg/100 g and 38.58 mg/100 g, respectively), leaf K content (211.09 mg/100 g, 207.94 mg/100 g and 209.52 mg/100 g, respectively) and leaf S content (0.39%, 0.37% and 0.38%, respectively) were observed with the treatment of no mulch (M_1).

The positive effect of black mulch (M_2) on plant vegetative growth might be due to better moisture availability 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) whereas, comparatively poor plant growth was reported under no mulch conditions due to lower soil moisture hampering plant growth and development in onion. Manganelli (2017) reported lower soil temperature under white and silver plastic mulches than black plastic mulch due to the higher reflection of light radiation by white and silver plastic mulches which prevent higher temperature buildup under the plastic covered root zone of plants in tomato. Ashrafuzzaman *et al*. (2011) recorded leaf chlorophyll content in chilli in black plastic mulch as compared to bare soil.

CONCLUSION

Therefore, it can 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 land configurations and black mulch was successfully attempted with the improved quality and nutrient content of onion during 2020-21, 2021-22 and pooled analysis. Hence, irrigation at 0.8 IW/CPE, raised bed configurations and black mulch may be recommended for *rabi* onion cultivation under the soil and agro climatic conditions of Western Rajasthan for higher profitability due to higher quality of onion.

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Conflict of interest

The all authors declare that they have no conflict of interests/ competing interests.

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