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Impact of different water stress regimes on the growth parameters of onion varieties

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Abstract

The experiment was conducted to examine the effect of various water stress levels on two varieties (V_1: Swat 1, V_2: Swat) of onion crop (*Allium cepa*. L) during the *Rabi* season 2015, and used RCBD with split plot arrangements of three replicates on clay loam soil. The stress levels comprised of full irrigation (I_o), 90% of full irrigation (I_1), 80% of full irrigation (I_2) and 70% of full irrigation (I_3). The soil moisture was determined by using FDR. Based on statistical results, the number of leaves (9.06) of both varieties at I_0 was more as compared to the given stress conditions. The plant height was significantly influenced by the irrigation levels. Moreover, the data reflected that plant height was maximum (65.7 cm) at I_o, while under the stress condition (I_3), the plant height was minimum (48.7 cm). The maximum leaf length was observed at I_0 (full irrigation) whereas, minimum value was obtained in I_3 (28.82 cm). It was observed from the mean data that the maximum leaf width was 1.1 cm, 1.077 cm, 0.928 cm, and 0.796 cm at I_0, I_1, I_2 and I_3 respectively. Bulb diameter of onion crop was significantly influenced by the irrigation levels however; the effect on varieties and the interaction between varieties and irrigation were non-significant. Percent Rotten Bulb in each treatment was not significantly influenced by the irrigation levels. Hence, both varieties showed same average values of the percent rotten bulb (9% each). Number of roots per plant showed less difference among all the treatments. It was clear from the data that the root length was highly affected by the irrigation levels. The minimum root length (21.9 cm) was observed at the application of I_1 while the maximum root length (29.15 cm) was noticed at I_3. The maximum bulb yield of onion crop (2.85 tons ha^{-1}) was obtained when treated with I_0. Therefore, it is concluded that both varieties showed negative response to extreme deficit irrigation levels below 90% while higher irrigation stress levels gave positive response in terms of yield and water use efficiency.

Keywords: Stress levels, Quantitative Growth Parameters, Onion

1. Introduction

Agriculture is one of the largest sources of Pakistan's economy. An overwhelming majority of the country is directly or indirectly adhered to this sector since ages. Around quarter of the Gross Domestic Product (GDP) is contributed by Agriculture and absorbed nearly half of employed labour force and is the largest source of foreign exchange earnings. All the population of country either rural or urban is dependent on Agriculture as main source of bread and butter. Onion (*Allium cepa* L.) is one of the important crops which belong to family Alliacea and sub-family Amaryllidaceae. It is considered that the origin of Onion was Near East. It is a monocotyledon crop and produced from seeds. The seedlings soon after one month are shifted to fields. The main edible portion of the onion plant is underground bulb and fleshy leaves, the bulb is formed underground and stem is made of flashy thick leaves [6]. The onion can be grown in a wide range of climatic conditions temperate to tropical. Onion (*Allium cepa* L.) is sensitive to deficit irrigation; the water depletion in the soil

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should not exceed 25% of the available soil water. Management allowed deficit is 25 %.

The crop requires frequent but light number of irrigations which are time bound. When about 25 percent of the available water in the first root of soil depth has been depleted by the crop irrigation application every 2-4 days is common practice. Spreading of diseases sometime is caused by over irrigation such as mildew and white rot. Before harvest (15 to 25 days) irrigation can be discontinued. Most common irrigation methods are furrow and basin irrigation. For the optimum yield (seasonally), onion crop requires 350 – 550 mm water. The Kc values at initial stage, crop developmental stage, mid-season, late season and at harvesting stage are 0.4-0.6, 0.7-0.8, 0.95-1.1, 0.85-9.0, 0.75-0.85 [3].

Globally, onion production is approximately 86.34 million tons and Pakistan's share is 2.25% with 8th position in terms of production [4]. Country wise, the highest production is from China with share of 28.68%. Whereas, India shares about 18.45%, the United States shares 3.89%, Iran, Egypt, Turkey, Russia and Pakistan shares 2.90%, 2.66%, 2.48%, 2.46%, and 2.25% respectively. Globally, onion is one of the important condiments being used. Such as, pickling, chutney, sauces as well as directly consumption for dehydration. Both cooked and uncooked onion is being used. Furthermore, it is also used as salad (when eating green onions). Most of the varieties of onion have been grown for salad purposes. A recent study showed that in order to prevent heat stroke and other diseases onion may play an important role. Important element like phosphorus, calcium and carbohydrates are found abundantly in onion bulb. Onion bulbs have special properties which help in digestion process and that property of onion is called diuretic properties. Some eye diseases can also be treated, and it act as cardiac stimulant and can also be used for anti-rheumatic cures [12].

Onion has its own unique flavor and it also enhances the taste of various kinds of dishes, salads, sandwiches and soups. Its pungent smell and strong flavor is due to presence of volatile oil and allyl-propyl di-sulphide. The yield is affected by the size and weight of the onion seeds. In addition, good quality of seed is the core input. Furthermore other variables inputs which affect the yield of onion are soil, water, climate, light weight, age of the plant, the quality of seeds, planting date and the distance between plants [1]. The onion bulb (edible portion) per 100 g composed of 34kcal energy, 95% water, 1.2 g protein, 7.3 g carbohydrates 0.3 g fat, 0.4 mg of the fiber, 5 mg sodium, 25 mg calcium, 0, 4 mg iron, 29 mg of phosphorus, and 155 mg of potassium.

2. Materials and Methods

A field based experiment was conducted to study the effect of various water stress levels on different varieties of onion crop, at Agricultural research farm of the University of Agriculture Peshawar, Khyber Pakhtunkhwa which is located at 34.02^{o} N and 71.46^{o} E. The experiment was considered on two varieties Swat-1 (V_1) and Swat (V_2) of Onion crop with four water stress levels i.e. 100% of MAD (Controlled), 90% of MAD (I_1), 80% of MAD (I_2) and 70% of MAD (I_3) using Randomized Complete Block (RCB) design with split plot arrangements and three replications. The Management Allowed Deficit (MAD) of Onion crop was 25% and average depth of root zone was 60 cm. To improve physical properties of soil (soil aeration and good water penetration), tillage was. Then a layout was assigned to separate the area for various varieties and irrigation levels. The combinations of treatment were randomly marked to each plot with the help of random number table.

3. Results and Discussions

3.1 Number of Leaves per Plant

Change in number of leaves per plant showed the vigorousity of the onion crop which is directly related to potential yield of the crop. In this regard, data about number of leaves per plant is presented in Table 1. The statistical analysis indicated that number of leaves was significantly influenced by irrigation levels. The interaction between irrigation and varieties also showed significant difference in the number of leaves per plant. While, varieties showed non-significant effect. The mean table revealed that at full irrigation (I_o), maximum number of leaves per plant was 9.06. Whereas, at 70% of full irrigation (I_3), the minimum value of leaves per plant were 6.23. Furthermore, it was revealed that I_1V_2 performed well with maximum number of leaves per plant (8.16) in stress conditions. The reason behind the reduction in number of leaves per plant with the increase in deficit irrigation could be due to the influence of the moisture on the rate of leaf initiation and the leaf life. These results showed similarities with the

findings of Kadayifci *et al.* (2005) [7] and Biswas, Khair, and Sarker (2010) [2] who stated that the decrease of leaves number with the deficit irrigation.

Table 1. Mean values of number of leaves per plant of different varieties of onion crop affected by different irrigation levels.

Irrigation levels	Varieties		Mean
	V_1	V_2	
I_0	9.06	9.06	9.06 a
I_1	7.26	8.16	7.71 b
I_2	7.30	7.02	7.16 c
I_3	6.36	6.23	6.30 d
Mean	7.495	7.6175	

LSD value at 5% level of significance for irrigation levels = 0.52

LSD value at 5% level of significance for interaction of I x V = 0.46

3.2. Plant Height

The data regarding plant height of onion crop is given in Table 2. The statistical analysis indicated that plant height was significantly influenced by irrigation levels however, there was non-significant impact on varieties. The interaction between varieties and irrigation also showed non-significant effect on plant height of the onion crop. From the mean data, it is clear that for the irrigation levels the plant height were significantly inferred, moreover at full irrigation (I_0) the plants were having maximum height (65.72 cm) but at stress condition the plant heights showed minimum values, the lowest height was recorded at 70% of the full irrigation (I_3) (48.791 cm). However, the results regarding plant height of I_0 and I_1 had no significant difference. These results are in line with the findings of Kadayifci *et al.* (2005) [7] and Biswas *et al.* (2010) [2] who observed the higher plant height (cm) at shorter duration of irrigation. This may be due to the result on the plant growth that is related to its effect on cell division, cell wall synthesis and expansion [10]. In fact, when the amount Readily Available Water (RAW) is reduced by applying stress condition then the plant starts exerting more pressure (suction) to draw water. Thus, cell division and expansion of the cell wall become lower, resulting in a shorter plant height.

Table 2. Mean values of Plant Height of different varieties of onion crop affected by different irrigation levels

Irrigation levels	Varieties		Mean
	V_1	V_2	
I_0	65.68	65.75	65.72 a
I_1	61.48	61.50	61.49 a
I_2	54.48	55.39	54.94 b
I_3	49.42	48.16	48.79 c
Mean	57.77	57.70	

LSD value at 5% level of significance for irrigation levels = 4.45

3.3 Leaf Length

The finding about leaf length is shown in Table 3. The statistical results indicated that the effect of irrigation levels on leaf length was significant. The interactive effect of irrigation and variety was also found significant at same level of probability; however the effect on varieties was non-significant. Furthermore, the mean data revealed that the full irrigation were having highest measurement of leaf length (51.22), while at 70% of full irrigation (I_3), lowest measurement (28.82) was recorded. The difference in leaf length of both varieties was could be due to the genetically variation or potentiality of different onion varieties. Shah *et al.* (2012) [11] conducted experiment on swat 1 and measured the leaf length between 36 and 40 cm. However, finding of this research regarding leaf length contradict the work of Shah *et al*. (2012) [11].

Table 3. Mean values of Leaf Length (cm) of different varieties of onion crop affected by different irrigation levels

Irrigation levels	Varieties		Mean
	V_1	V_2	
I_0	49.97	52.48	51.22 a
I_1	45.22	44.14	44.68 b
I_2	37.69	34.89	36.29 c
I_3	30.19	27.46	28.82 d
Mean	40.77	39.74	

LSD value at 5% level of significance for irrigation levels = 4.35

LSD value at 5% level of significance for interaction of IxV = 2.34

3.4 Leaf Width

The data was recorded regarding leaf width of onion crop, and their mean data is presented in Table 4. The result revealed that the effect of irrigation on leaf width was significant, but the effect of varieties showed non-significant effect and the interaction

between irrigation and variety was also non-significant at the 5% level of probability. From the mean table, maximum leaf width (1.18 cm) was obtained at I_o but at I_3 the minimum value was obtained for leaf width (0.79 cm).

Table 4: Mean values of Leaf Width (cm) of different varieties of onion crop affected by different irrigation levels

Irrigation levels	Varieties		Mean
	V_1	V_2	
I_0	1.15	1.22	1.18 a
I_1	1.11	1.04	1.07 a
I_2	0.97	0.88	0.92 b
I_3	0.72	0.86	0.79 b
Mean	0.99	1.00	

LSD value at 5% level of significance for irrigation levels = 0.14

3.5 Bulb Diameter

Data regarding Bulb Diameter of onion crop was recoded and the mean values are presented in Table 5. The result showed that the effect of irrigation levels on bulb diameter was significant but the effect on varieties showed non-significant effect along with the interaction between varieties and irrigation showed non-significant. The mean data showed that at full irrigation (I_o), the mean value for the both varieties is 5.86 (cm) which is the maximum among all the values of I_1, I_2, and I_3. The minimum value for bulb diameter was obtained at I_3 (3.91). These findings regarding were similar to Orta and Sener (2001) [8], who observed the bulb diameter ranged from 5.6 cm to 3.82 cm under stress conditions.

Table 5: Mean values of Bulb Diameter (cm) of different varieties of onion crop affected by different irrigation levels

Irrigation levels	Varieties		Mean
	V_1	V_2	
I_0	5.92	5.81	5.86 a
I_1	5.46	5.47	5.46 ab
I_2	4.88	5.00	4.94 b
I_3	4.09	3.91	4.00 c
Mean	5.09	5.04	

LSD value at 5% level of significance for irrigation levels = 0.75

3.6 Bulb Yield

The average bulb yield for V_1 and V_2 was calculated (2.44 tons ha^{-1} and 2.40 tons ha^{-1} respectively). The statistical analysis as shown in Table 6 indicated that yield was significantly influenced by the irrigation levels but the varieties showed non-significant effect and the interaction between irrigation and varieties had a non-significant effect on yield too. Maximum yield was obtained at full irrigation (I_1) (2.85 tons ha^{-1}) while 70% of the full irrigation (I_3) gave minimum yield (1.99 tons ha^{-1}). There was 28.8% decrease in the yield between I_0 and I_3 in case of V_1, while for the V_2 the decrease in the yield was 31.3%. Patel and Rajput (2013) [9] reported that the maximum yield was observed in full irrigation and the minimum yield was observed in the lowest application of water. These results showed that V_1 performed better, this might be due to better survival percentage and proper amount of water application per unit area. The results are correlated with the findings of Gamie, Mohamed, El-Aref, and Massoud (2000) [5], who observed that varieties have different potential of total yield production and behaved differentially at variable moisture status.

Table 6. Mean values of Yield (tons ha^{-1}) of different varieties of onion crop affected by different irrigation levels

Irrigation levels	Varieties		Mean
	V_1	V_2	
I_0	2.88	2.81	2.85 a
I_1	2.68	2.66	2.67 b
I_2	2.15	2.18	2.16 c
I_3	2.05	1.93	1.99 d
Mean	2.44	2.40	

LSD value at 5% level of significance for irrigation levels = 1203.5

3.8. Percent Rotten Bulb

After harvesting, the percent rotten bulb was calculated for each treatment and their mean values are shown in Table 7. The statistical analysis indicated that percent of rotten bulb was significantly influenced by irrigation levels, however the varieties showed non-significant effect along with results which showed that interaction of varieties and irrigation had non-significant effect. The mean table reveals that at full irrigation (I_o), maximum number (11.33 %) of rotten bulb was

obtained while at (I_3) 70% of the full irrigation minimum value (7.00 %) was obtained. On top of that, there was no significant difference between the mean values of I_1 and I_2.

Table 7. Mean values of Rotten Bulb of different varieties of onion crop affected by different irrigation levels

Irrigation levels	Varieties		Mean
	V_1	V_2	
I_0	10.66	12.00	11.33 a
I_1	9.33	7.33	8.33 ab
I_2	8.66	10.00	9.33 ab
I_3	7.33	6.66	7.00 b
Mean	9.00	9.00	

LSD value at 5% level of significance for irrigation levels = 3.41

3.8 Number of Roots per Plant

The Table 8 shows mean value for number of root per plant. The statistical analysis revealed that irrigation and varieties showed non-significant impact on number of root per plant in all the treatments, also the interaction between irrigation and varieties showed non-significant effect on number of root per plant. The maximum value observed in I_3 was 25.05 root per plant, while the minimum mean value found in I_0 was 22.86 root per plant.

Table 8. Mean values of number of root per plant of different varieties of onion crop affected by different irrigation levels

Irrigation levels	Varieties		Mean
	V_1	V_2	
I_0	26.13	23.83	24.98
I_1	19.73	26.00	22.86
I_2	25.41	21.73	23.57
I_3	24.25	25.76	25.05
Mean	23.88	24.33	

3.9 Root Length

Mean data regarding root length is tabulated in Table 9. The result of statistical analysis indicated that the effect of irrigation levels on root length was significant but the effect on varieties and the interaction between varieties and irrigation was non-significant.

The mean data in Table 9 showed that at 90% of full irrigation (I_1) the mean value for the both varieties was 21.89 cm which was the minimum length of the root, while at 70% of full irrigation (I_3) maximum value were obtained (29.150 cm). Importantly, I_1 and I_2 showed no significant differences. The increase in root length under deficit irrigation was might be due to water scarce condition in which roots tried to go deep for searching of water.

Table 9. Mean values of Root Length (cm) of different varieties of onion crop affected by different irrigation levels

Irrigation levels	Varieties		Mean
	V_1	V_2	
I_0	23.85	24.66	24.25 b
I_1	21.55	22.23	21.89 c
I_2	21.43	22.76	22.10 c
I_3	30.16	28.13	29.15 a
Mean	24.25	24.45	

LSD value at 5% level of significance for irrigation levels = 1.67

4. Conclusion

It is concluded that the maximum leaf width was 1.1 cm, 1.077 cm, 0.928 cm, and 0.796 cm at I_0, I_1, I_2 and I_3 respectively. Bulb diameter of onion crop was significantly influenced by the irrigation levels however; the effect on varieties and the interaction between varieties and irrigation were non-significant. Percent Rotten Bulb in each treatment was not significantly influenced by the irrigation levels. Hence, both varieties showed same average values of the percent rotten bulb (9% each). Number of roots per plant showed less difference among all the treatments. It was clear from the data that the root length was highly affected by the irrigation levels.

The minimum root length (21.9 cm) was observed at the application of I_1 while the maximum root length (29.15 cm) was noticed at I_3. The maximum bulb yield of onion crop (2.85 tons ha^{-1}) was obtained when treated with I_0. Therefore, it is concluded that both varieties showed negative response to extreme deficit irrigation levels below 90% while higher irrigation stress levels gave positive response in terms of yield and water use efficiency.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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