IMPROVING YIELD, STORABILITY AND WATER PRODUCTIVITY FOR SOME ONION CULTIVARS BY DIFFERENT PLANTING METHODS

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ABSTRACT

The current experiment was carried out in a clay soil at Sids Agricultural Research Station, Beni-Swief Governorate Egypt during the two seasons of 2013/2014 and 2014/2015 to study the effect of planting methods on productivity and storability as well as crop-water relations for some onion cultivars. Three planting methods: planting on flat land (P_1), on ridges (P_2) and on raised bed (P_3). Three cultivars namely, Giza 6 Mohassan (C_1), Giza 20 (C_2) and Giza red (C_3). The split-plot experimental design in four replicates were performed, where planting methods were occupied the main plots while the split ones were allocated to the onion cultivars. The important findings could be summarized as follows:-

* Amount of irrigation water applied and seasonal consumptive use under P_3 treatment were reduced in comparison with those under P_1 and P_2 for all cultivars in the two seasons.

* The highest averages of plant height, no. of leaves/plant, bulb length, no. of days to maturity and TSS % in the two successive seasons, were detected from planting onion on ridges of 60 cm width (P_2). While, bulb diameter, plant weight and dry matter % were detected for planting onion on raised bed (P_3) for all onion cultivars.

* The marketable onion, total yields and bulb weight were increased with P_3 comparable with P_1 and P_2. The lowest value of culls onion yield was obtained with P_1 compared with P_2 and P_3 for all cultivars in the two seasons.

* Water productivity and water use efficiency values were improved under P_3 as compared with the values with P_1 and P_2 for all cultivars in the two seasons.

* Planting onion on raised bed (P_3) for all onion cultivars resulted in significant decrease in weight loss % at different storage periods, in both seasons.

Key words: Onion, yield, planting methods, onion cultivars, water productivity and storability.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important vegetable crops grown in Egypt, not only for local consumption but also for exportation. The crop production of onion is affected by many factors such as cultivars, fertilization requirements, agricultural practices and irrigation management. Ridge width and plant distance are two factors affecting bulbs diameter, size and weight.

Soil moisture is one of the most important factors that influence onion yield. Onion have a shallow and limited root system and requires frequent irrigation as the crop extract very little water **(Ali *et al.,* 2007)**. This crop should be irrigated frequently throughout the growing season. Moisture is important in the growth of new roots, the soil moisture must reach the base of the bulb periodically if the newly formed roots from the stem are to grow into the soil. New roots will not grow in dry soil **(EARO, 2004)**. Bulbs grown under low soil moisture regimes are usually smaller and tend to loss more moisture and dry earlier during storage **(Maw and Mullinix, 2005)**.

In this respect, **Ashry *et al.* (2008)** found that increasing ridge width to be 120 cm decreased seasonal evapotranspiration (ETc), while water use efficiency (WUE) was increased, comparable with 60 cm ridge width. **Aggarwal and Goswami (2003)** also reported that under sandy loam soil with three rows of wheat per bed, bed-planting wheat yield and water productivity (WP) increased by 0.22 and 0.03 ton ha^{-1} cm^{-1}, respectively, compared to flood irrigation in conventional flat planting. **Fahong *et al.* (2004)** found that nitrogen use efficiency (NUE) could be improved by 10% or more in furrow irrigated bed-planting systems, because of improved N placement possibilities. Also, the microclimate within the field was changed to the orientation of the wheat plants in rows on the beds, which reduced crop lodging and decreased the incidence of some wheat diseases. These advantages were found to improve grain quality and increase grain yield by more than 10%. **Zhang *et al.* (2007)** also reported that furrow irrigated raised bed-planting (FIRB) had higher water productivity (WP) than FP due to lower water consumption and higher yields. In conclusion, Furrow irrigated raised-bed planting has been suggested to be one of the most effective measures to reduce the cost of cultivation and to increase WP as well as to optimize yield. **Ahmad *et al.* (2010)** revealed that bed and furrow irrigation methods not only provided better drainage under heavy rains but also saved more than 35% of irrigation water as compared to flat methods and experienced more crop yield. Saving of irrigation water accompanied by improvement in yield is a breakthrough for the farmers having shortage of good quality water. It is therefore, recommended that the bed furrow irrigation method should be encouraged particularly for efficient utilization of water resources and improving wheat productivity in soils. **El-Akram (2012)** in Egypt, stated that onion bulb yield and water use were higher with frequently irrigation, i.e., irrigating at 40% of available soil moisture was depleted, in comparison with irrigation at 60 and 80% ones. Indubitable, irrigation management affecting onion yield-water relations. **Abu-Awwad (1999)** reported that water use efficiency for onion, in the covered soil surface treatment, was maximum for the highest water level (197 mm irrigation). In this sense, **Kadayifci *et al.* (2005)** found that high water use and water use efficiencies were observed with increasing levels of irrigation in the vegetative period. Irrigation is an important factor influencing onion storability, **Rabbani *et al.* (1986)** reported that storage losses in onion could be as high as 66%, and many factors, such as cultivars, bulb maturity, moisture content of the bulb, temperature, relative humidity, etc. are associated with deterioration of onion during storage. In addition, a substantial increase of decomposition in onion during storage with increasing irrigation was reported by **Shock *et al.* (1998)**. On the other hand, **Soujala *et al.* (1998)** reported that irrigation had only a minor effect on the storage performance and shelf life of onion.

The aim of this study is to investigate the effect of three planting methods on productivity and storability as well as crop-water relations for some onion cultivars under Beni-Swief Governorate.

MATERIALS AND METHODS

The present research trial was conducted in 2013/2014 and 2014/2015 growing seasons at the Experimental Farm of Sids Agricultural Research Station, Beni-Swief Governorate (Middle Egypt, Lat. 29º 04' N, Long. 31º 06' E and 30.40 m above the mean sea level). The soil moisture constants, some physical properties (according to **Klute, 1986**) as well as some chemical properties of the soil experimental site according to **Ryan *et al.* (1996)** are listed in Tables (1) and (2). The trial aimed to investigate the performance of three planting methods under three onion cultivars besides their interactions on onion crop growth, bulbs yield and storability as well as crop water consumptive use and water productivity.

Table (1): Some soil water constants for the experimental site (2013/2014 and 2014/2015 seasons).

Season	Depth (cm)	Field capacity (%)	Wilting point (%)	Bulk Density (g cm^{-3})	Available water (%)
2013/2014	00 – 15	45.08	21.58	1.131	23.50
	15 – 30	37.95	18.04	1.244	19.91
	30 – 45	35.95	17.32	1.285	18.63
	45 – 60	33.14	16.04	1.328	17.10
Mean		38.03	18.25	1.247	19.79
2014/2015	00 – 15	46.56	22.17	1.170	24.39
	15 – 30	37.09	17.66	1.299	19.43
	30 – 45	35.55	16.92	1.357	18.63
	45 – 60	33.19	15.80	1.379	17.39
Mean		38.10	18.14	1.301	19.96

Table (2) : Some physical and chemical properties of the experimental site

Season	Particle size distribution			Textural class	Chemical properties					
	Clay %	Silt %	Sand %		OM. %	E.C. (dS/m at 25°C)	Available (ppm)			pH
							N	P	K	
2013/2014	49.90	33.75	16.35	Clay	2.25	0.65	23.00	15.5	210.5	7.9
2014/2015	50.35	32.32	17.33		2.10	0.70	22.02	17.0	205.8	7.8

The experiment was laid out in split plot experimental design with four replicates. Planting methods were allocated to the main plots, while the assessed onion cultivars were occupied the split ones as follows:-

1- Main plots (Planting methods)

P_1 = Planting on flat land (traditional)

P_2 = Planting on ridges (60 cm)

P_3 = Planting on raised bed (120 cm)

2- Sub plots (Onion cultivars)

C_1 = Giza 6 Mohassan C_2 = Giza 20 C_3 = Giza red

The nursery were sown at the first week from September in two seasons. Seedlings were transplanted after 55 to 60 days after planting. The plot size was 6 m width x 7 m length (1/100 fed). The seedling were transplanted at spacing of 10 cm between plants and 20 cm between rows. Fertilization was applied according to the recmmendation of the Ministry of Agriculture in Egypt as follows: 31 kg P_2O_5/fed as supper phosphate (15.5% P_2O_5) during land preparation, 120 kg N/fed ammonium nitrate (33.5%) in two equel doses, the first before the first irrigation and the second one manth later and 48 kg K_2O/fed as potassium sulphate (48% K_2O) in two equal doses as in case of nitrogen. All the reconmmended cultural practices for onion production were applied and adapled to surface irrigation conditions. The applied irrigation water was measured using a water meter attached to the irrigation pump. The onion plants were grown to maturity and were considered mature when 50 % of leaves fall down. At 105 days post planting, a representative sample of ten plants from each plot was randomly taken to measure plant height, number of leaves per plant, bulb diameter, bulb length, plant and bulb weight, dry matter percentage and days to maturity. At harvest time, when 50% of leaves fell down, the remaining plants in each plot were harvested and cured in the field for 10 days, then the shoots and roots were removed. The marketable, culls and total bulb yields from each sub-plot were recorded and expressed in t/fed. In addition, for storability determination, about 150 bulbs were stored under room temperature condition and weight losses (%) after 2, 4 and 6 months were recorded.

The data collected for the studied variables were subjected to statistical analysis using Analysis of Variance (ANOVA) technique (**Senedecor and**

Cochran, 1980). The means were compared using Least Significant Difference (LSD) at 5% level according to **Waller and Duncan, (1969)**.

<u>Crop - water relationships</u>:

Seasonal consumptive use (CU)

On determining the crop water consumptive use (CU), soil samples were taken just before and 48 hours after each irrigation, as well as at harvest time in 15 cm increment system to 60 cm depth of the soil profile. The crop water consumptive use between each two successive irrigations was calculated according to **Israelsen and Hansen, 1962.**

$$Cu = \frac{D.Bd.[Q2 - Q1]}{100}$$

Cu = Actual consumptive use (cm)
D = Effective root zone depth (cm).
Bd = Bulk density of soil (g cm^{-3}).
Q2 = Soil moisture percentage (wt/wt) two days after irrigation.
Q1 = Soil moisture percentage (wt/wt) just before the next irrigation.

Water Productivity (WP)

Water productivity is an efficiency term calculated as a ratio of product output over water input. The output could be biological goods such as crop grain, fodder, bulbs ….etc. So, water productivity, in the present study, is expressed as kilogram of onion bulbs obtained per the unit of applied irrigation water. The water productivity values was calculated for different treatments as follows:

WP (kg/m^3) = Bulb yield (kg/fed) / water applied (m^3/fed), **FAO (2003).**

Water use efficiency (WUE)

The water use efficiency as kg onion bulb/m^3 water consumed was calculated for different treatments as described by **Vites (1965):**

WUE (kg/m^3) = Bulb yield (kg/fed) / consumptive use (m^3/fed)

RESULTS AND DISCUSSION

Irrigation water applied (IWA):

Data in Table (3) show that the highest values of amount of applied water was produced under planting on flat land (traditional P_1) which recorded the maximum values of 2435 m^3/fed (57.98 cm) and 2528 m^3/fed (60.19 cm) in the two seasons, respectively. On the other hand, the lowest values of 1962 m^3/fed (46.71 cm) and 1983 m^3/fed (47.21 cm) were obtained due to planting on raised bed 120 cm (P_3), while the planting on ridges 60 cm (P_2) recorded 2179 m^3/fed (51.88 cm) and 2241 m^3/fed (55.05 cm). The data revealed that (P_3) could save about 19.43 and 9.96%; and 21.56 and 11.51% of applied irrigation water compared to P_1 and P_2 in the two seasons, respectively. Similar results were reported by **Ahmad *et al.* (2010).**

Generally, increasing amount of irrigation water applied for P_1 compared with planting method (P_2 and P_3) may be attributed to the wetted area of P_1 which was more than treatment P_2 or P_3. Where, in both treatments P_2 and P_3 irrigation water was added to bottom of furrows only, in addition to small part for both sides of furrows as a result of water flow in bottom of furrows. Accordingly, wetted area treatments P_2 and P_3 was less than traditional method P_1. Also number of bottom of furrows with the treatment P_3 were less than treatment P_2 by 50 %.

Table (3): Effect of planting methods on irrigation water applied (IW) for three onion cultivars in 2013/2014 and 2014/2015 seasons.

Planting method (P)	Cultivars (C)	IW					
		m^3/fed			cm		
		First season	Second season	Overall mean	First season	Second season	Overall mean
P_1	C_1	2325	2451	2388	55.36	58.36	56.86
	C_2	2475	2500	2488	58.93	59.52	59.24
	C_3	2505	2633	2569	59.64	62.69	61.17
Mean		2435	2528	2482	57.98	60.19	59.10
P_2	C_1	2110	2180	2145	50.24	51.90	51.07
	C_2	2202	2231	2217	52.43	52.69	52.79
	C_3	2225	2312	2269	52.98	55.05	54.02
Mean		2179	2241	2210	51.88	53.36	52.62
P_3	C_1	1901	1939	1920	45.26	46.17	45.71
	C_2	1975	1980	1978	47.02	47.14	47.10
	C_3	2010	2030	2020	47.86	48.33	48.10
Mean		1962	1983	1973	46.71	47.21	46.98
Mean of cultivars	C_1	2112	2190	2151	50.29	52.41	51.21
	C_2	2217	2237	2227	52.79	53.26	53.02
	C_3	2247	2325	2286	53.50	55.36	54.43

(P_1, P_2 and P_3 planting methods: Planting on flat land (traditional), ridges (60 cm) and raised bed (120 cm); (C_1, C_2 and C_3) Cultivars: Giza 6 Mohassan, Giza 20 and Giza Red, respectively

Results show that Giza red (C_3) cultivar used higher quantity of (IW) than Giza 6 Mohassan (C_1) and Giza 20 (C_2) cultivars in the two seasons, respectively. The Giza red (C_3) consumed water higher than Giza 6 Mohassan (C_1) and Giza 20 (C_2) by about 135 and 30 m^3/fed and 135 and 88 m^3/fed in the two growing seasons, respectively, this means that the three cultivars did not differ clearly from each other.

Seasonal consumptive use (CU):

Crop water consumptive use was computed on the basis of water depletion from the effective root zone of the upper 60 cm soil depth. Results in Table (4) reveal that, seasonal CU for onion clearly was affected by planting methods in the two growing seasons. Concerning the effect of planting methods, the highest values were recorded under planting method P_1 compared with the other planting methods (P_2 and P_3). The highest mean values were 2046 m^3/fed (48.71 cm) and 2135 m^3/fed (50.80 cm) by the traditional method (P_1), while the lowest were 1658 m^3/fed (39.48 cm) and 1775 m^3/fed (42.26 cm) by P_3 in the two seasons, respectively. In 2013/2014 season, the increase in water consumptive use for crop due to P_1 reached 13.98 and 23.40% more than those recorded under P_2 and P_3 treatment, respectively. Similar trends were observed in 2014/2015 season. **Doorenbos and Pruitt (1977)** gave an extensive explanation of the effect of available soil water on evapotranspiration, they stated that after irrigation or rain the water content will be reduced primarily by evapotranspiration. They added that as the soil was dried, the rate of water transmitted through the soil will reduce. The effect of soil water content on evapotranspiration varies with crop and soil type, as well as water holding characteristics.

Table (4): Effect of planting methods on water consumptive use (CU) for three onion cultivars in 2013/2014 and 2014/2015 seasons.

Planting method (P)	Cultivars (C)	CU					
		m^3/fed			cm		
		First season	Second season	Overall mean	First season	Second season	Overall mean
P_1	C_1 C_2 C_3	1995 2033 2110	2065 2122 2218	2030 2078 2164	47.50 48.40 50.24	49.17 50.52 52.81	48.33 49.48 51.52
Mean		2046	2135	2091	48.71	50.83	49.99
P_2	C_1 C_2 C_3	1760 1800 1825	1830 1908 1950	1795 1854 1888	41.90 42.88 43.45	43.57 45.43 46.43	42.74 44.14 44.95
Mean		1795	1896	1846	42.74	45.14	43.95
P_3	C_1 C_2 C_3	1615 1655 1705	1725 1795 1805	1670 1725 1755	38.45 39.40 40.60	41.07 42.74 42.98	39.76 41.07 41.79
Mean		1658	1775	1717	39.48	42.26	40.88
Mean of cultivars	C_1 C_2 C_3	1790 1829 1880	1873 1942 1991	1832 1886 1936	42.62 43.55 44.76	44.60 46.24 47.40	43.62 44.90 46.10

(P_1, P_2 and P_3 planting methods: Planting on flat land (traditional), ridges (60 cm) and raised bed (120 cm); (C_1, C_2 and C_3) Cultivars: Giza 6 Mohassan, Giza 20 and Giza Red, respectively

Regardless the adopted planting methods, data in Table (4), reveal that, in 2013/2014 season, Giza red onion cultivar exhibited the highest water consumptive use value reached to 5.03 and 2.79% more than those recorded for Giza 6 Mohassan and Giza 20 ones, respectively. In 2014/2015 season, these increases reached to 6.30 and 2.52% in the same order, respectively.

The results indicate that Giza red cultivar exhibited higher water consumptive use under planting on flat land (P_1), while Giza 6 Mohassan recorded the lowest water consumptive use in the two seasons.

Growth characters:

The results in Table (5 and 6) clear that planting methods significantly affected plant height, number of leaves/plant, bulb diameter, bulb length, plant weight and days to maturity in both seasons. Ridges methods appeared higher values of plant height (74.28 and 75.02 cm), number of leaves/plant (8.29 and 8.40), bulb length (6.54 and 7.11 cm) and days to maturity (139.50 and 139.75), while raised bed methods appeared the highest values of bulb diameter (7.12 and 7.42 cm) and plant weight (218.59 and 228.65 g) in the first and second seasons respectively. Flat land (traditional) method attained the lowest values of all growth characters in both seasons, except for plant height in the first season and bulb length in the second one.

Table (5): plant height (cm), number of leaves/plant and bulb diameter for onion cultivars as affected by planting methods in 2013/2014 and 2014/2015 seasons.

Planting method (P)	Cultivars (C)	First season			Second season		
		Plant height (cm)	No. of leaves/ plant	Bulb diameter (cm)	Plant height (cm)	No. of leaves/ plant	Bulb diameter (cm)
P_1	C_1	57.35	6.50	5.78	60.60	5.18	5.78
	C_2	70.73	6.93	5.93	71.18	6.70	6.33
	C_3	71.10	7.25	6.08	74.10	7.75	6.33
Mean		66.39	6.89	5.93	68.63	6.54	6.15
P_2	C_1	66.83	7.50	6.13	66.20	7.73	6.25
	C_2	77.00	8.43	6.18	77.33	8.65	6.35
	C_3	79.00	8.95	6.90	81.53	8.83	6.73
Mean		74.28	8.29	6.40	75.02	8.40	6.44
P_3	C_1	62.70	7.13	6.38	64.45	6.85	6.60
	C_2	64.95	7.30	7.20	72.85	7.10	7.70
	C_3	67.93	8.55	7.78	76.45	8.60	7.95
Mean		65.19	7.66	7.12	71.25	7.52	7.42
Mean of cultivars	C_1	62.29	7.04	6.10	63.75	6.59	6.21
	C_2	70.89	7.55	6.44	73.79	7.48	6.79
	C_3	72.68	8.25	6.92	77.36	8.39	7.00
L.S.D at 5 %	(P)	3.58	0.65	0.24	3.52	0.65	0.17
	(C)	5.22	0.50	0.33	2.44	0.50	0.36
	(P X C)	9.04	0.87	0.57	4.23	0.87	0.62

Table (6): Bulb length, plant weight and No. of days to maturity for onion cultivars as affected by planting methods in 2013/2014 and 2014/2015 seasons.

Planting methods (P)	Cultivars (C)	First season			Second season		
		Bulb length (cm)	Plant weight (g)	Days of maturity	Bulb length (cm)	Plant weight (g)	Days of maturity
P_1	C_1	4.78	159.25	106.75	4.95	163.03	109.25
	C_2	5.25	182.58	141.00	5.80	187.73	141.00
	C_3	6.48	196.80	148.75	6.68	227.53	150.00
Mean		5.50	179.54	132.17	5.81	192.76	133.42
P_2	C_1	5.38	174.95	119.00	5.80	180.85	121.25
	C_2	7.08	217.88	144.75	7.48	223.10	143.25
	C_3	7.15	234.93	154.75	8.05	254.78	154.75
Mean		6.54	209.25	139.50	7.11	219.58	139.75
P_3	C_1	4.65	191.23	109.25	4.60	198.45	119.00
	C_2	5.20	226.20	138.00	5.08	226.98	138.00
	C_3	6.73	238.35	150.00	7.15	260.53	149.00
Mean		5.53	218.59	132.42	5.61	228.65	135.33
Mean of cultivars	C_1	4.94	175.14	11.67	5.12	180.78	116.50
	C_2	5.84	208.89	141.25	6.12	212.60	140.75
	C_3	6.79	223.36	151.17	7.29	247.61	151.25
L.S.D at 5 %	(P)	0.49	9.30	6.58	0.53	10.78	3.62
	(C)	0.30	8.61	3.33	0.60	16.41	3.63
	(P X C)	0.53	14.92	5.77	0.94	28.44	6.29

(P_1, P_2 and P_3 planting methods: Planting on flat land (traditional), ridges (60 cm) and raised bed (120 cm); (C_1, C_2 and C_3) Cultivars: Giza 6 Mohassan, Giza 20 and Giza Red, respectively

As shown in Table (5 and 6), plant height, number of leaves/plant, bulb diameter, bulb length, plant weight and days to maturity were significantly affected under different onion genotypes in both seasons. Giza Red cultivar attained the highest values of plant height (72.68 and 77.36 cm), number of leaves/plant (8.25 and 8.39), bulb diameter (6.92 and 7.00 cm), bulb length (6.79 and 7.29 cm, plant weight (223.36 and 247.61 g) and days to maturity (151.17 and 151.25), in the first and second seasons respectively. Giza 6 Mohassan showed the lowest values of all growth characters, in both seasons.

The differences between onion cultivars in respect to growth characters are mainly attribute to genetic variation between cultivars which appear differences in their performances, similar results were obtained by **Pal *et al.* (1988), Mohamed and Gamie (1999), El-Damarany and Obiadalla-Ali (2005)** and **Gamie and Yaso (2007).**

The interaction between planting methods and onion cultivars had significant effect on all the studied growth parameters, in the two seasons. The highest values of plant height, number of leaves/plant, days to maturity and bulb length in the both seasons were obtained under ridges methods when using Giza red cultivar. While, the lowest values of all studied growth parameters were obtained under flat land method when using Giza 6 Mohassan cultivar in the two seasons, except bulb length in the first season.

Bulb yield and its components:

Data recorded in Table (7) clear that planting methods significantly differentiated average bulb weight, marketable yield/fed, culls yield/fed, and total yield/fed, in both seasons. The greatest values of average bulb weight (129.11 and 134.75 g), marketable yield/fed (17.64 and 18.84 ton), culls yield/fed (1.72 and 1.84) and total yield/fed (19.38 and 20.51 ton) were obtained under raised bed planting methods, while the lowest values of average bulb weight (102.68 and 108.70 g), marketable yield/fed (15.35 and 16.76 ton), culls yield/fed (1.47 and 1.36) and total yield/fed (16.81 and 18.13 ton) were obtained under flat land methods, in the first and second seasons, respectively.

The results in Table (7) show significant differences among the means of the three cultivars in respect to average bulb weight, marketable yield/fed, culls yield/fed and total yield/fed in both seasons. The maximum means of bulb weight of (154.17 and 156.12 g), marketable yield (17.97 and 19.62 t/fed), culls yield (1.83 and 1.91 t/fed) and total yield (19.80 and 21.37 (t/fed) were recorded for Giza Red cultivar, while, the minimum means of bulb weight of (84.98 and 88.01 g), marketable yield (14.72 and 15.73 t/fed), culls yield (1.37 and 1.31 t/fed) and total yield (16.10 and 17.04 t/fed) were recorded for Giza 6 Mohassan cultivar. The differences among genotypes in respect to onion yield and yield components were stated by many investigators **(Mohanty and Prusti, 2001; Leilah *et al.*, 2003; El-Damarany and Obiadalla-Ali, 2005** and **Yaso, 2007)**.

Table (7): Bulb weight (g), marketable, culls and total bulb yields (t/fed.) for onion cultivars as affected by planting methods in 2013/2014 and 2014/2015 seasons.

Planting method (P)	Cultivars (C)	First season				Second season			
		Bulb weight (g)	Market. yield (t/fed)	Culls yield (t/fed)	Total yield (t/fed)	Bulb weight (g)	Market. yield (t/fed)	Culls yield (t/fed)	Total yield (t/fed)
P_1	C_1	69.43	14.02	1.35	15.37	74.15	14.38	1.00	15.39
	C_2	91.90	15.44	1.37	16.81	103.95	17.27	1.26	18.56
	C_3	146.70	16.58	1.68	18.25	148.00	18.64	1.81	20.45
Mean		102.68	15.35	1.47	16.81	108.70	16.76	1.36	18.13
P_2	C_1	89.29	14.86	1.37	16.23	90.95	15.52	1.35	16.87
	C_2	117.10	16.43	1.41	17.84	120.03	17.99	1.46	19.46
	C_3	153.80	17.65	1.78	19.43	155.58	19.32	1.83	21.16
Mean		120.06	16.31	1.52	17.83	122.19	17.61	1.55	19.16
P_3	C_1	96.23	15.29	1.40	16.69	98.93	17.28	1.57	18.85
	C_2	129.10	17.94	1.73	19.67	139.55	18.34	1.84	20.17
	C_3	162.00	19.69	2.03	21.72	164.78	20.90	2.10	22.51
Mean		129.11	17.64	1.72	19.38	134.75	18.84	1.84	20.51
Mean of cultivars	C_1	84.98	14.72	1.37	16.10	88.01	15.73	1.31	17.04
	C_2	112.70	16.60	1.50	18.11	121.18	17.87	1.52	19.40
	C_3	154.17	17.97	1.83	19.80	156.12	19.62	1.91	21.37
L.S.D at 5 %	**(P)**	8.31	0.32	0.12	0.35	8.74	0.54	0.20	0.45
	(C)	9.60	0.46	0.19	0.52	10.92	0.33	0.11	0.33
	(P X C)	16.60	0.80	0.34	0.91	18.93	0.58	0.19	0.58

(P_1, P_2 and P_3 planting methods: Planting on flat land (traditional), ridges (60 cm) and raised bed (120 cm); (C_1, C_2 and C_3) Cultivars: Giza 6 Mohassan, Giza 20 and Giza Red, respectively

Average bulb weight, marketable yield/fed, culls yield/fed, and total yield/fed were significantly affected by the interaction between planting methods treatments and onion cultivars, in the two seasons. The highest combinations for average bulb weight, marketable yield/fed, culls yield/fed, and total yield/fed were obtained under raised bed method, when using Giza Red cultivar, while the lowest ones were obtained under flat land method when using Giza 6 Mohassan in the two seasons.

Bulb quality:

Data listed in Table (8) indicate that the differences between the means of total soluble solids (TSS) % and dry matter % were significant in response to planting method treatments. Planting of onion seedlings on ridges appeared the highest value of TSS %, while planting it on flat land appeared the lowest one, in both seasons. planting of seedlings on raised bed showed the highest value of dry matter %, while planting it on flat land showed the lowest one, in the two seasons.

Table (8): Effect of planting methods on quality for onion cultivars bulbs in 2013/2014 and 2014/2015 seasons.

Planting method (P)	Cultivars (C)	First season		Second season	
		TSS %	Dry matter %	TSS %	Dry matter %
P_1	C_1	13.85	11.90	12.98	13.43
	C_2	13.90	13.15	13.83	12.98
	C_3	14.33	12.55	14.08	12.45
Mean		14.03	12.53	13.96	12.95
P_2	C_1	14.58	14.53	14.85	14.60
	C_2	14.80	14.15	14.88	13.68
	C_3	15.83	13.28	16.10	13.10
Mean		15.07	13.99	15.28	13.79
P_3	C_1	14.05	15.40	14.50	14.75
	C_2	14.45	15.05	14.60	14.35
	C_3	14.58	14.35	14.83	13.58
Mean		14.36	14.93	14.64	14.23
Mean of cultivars	C_1	14.16	13.94	14.11	14.26
	C_2	14.38	14.12	14.44	13.67
	C_3	14.91	13.39	15.00	13.04
L.S.D at 5 %	(P)	0.54	0.67	0.40	0.65
	(C)	0.49	0.62	0.43	0.44
	(P X C)	0.85	1.07	0.75	0.76

(P_1, P_2 and P_3 planting methods: Planting on flat land (traditional), ridges (60 cm) and raised bed (120 cm); (C_1, C_2 and C_3) Cultivars: Giza 6 Mohassan, Giza 20 and Giza Red, respectively

Data in Table (8) state that TSS % and dry matter% were significantly affected by different genotypes in both seasons. Giza Red variety surpassed the other two cultivars (Giza 6 Mohassan and Giza 20) in respect to TSS %, while it appeared the lowest value of dry matter % as compared to the two other cultivars, in the two season. The highest value of dry matter % was obtained by using Giza 20 in the first season, and Giza 6 Mohassan in the second season. While, the lowest values of TSS % were obtained by using Giza 6 Mohassan, in the two seasons.

The results obtained in Table (8) reveal that TSS % and dry matter % was significantly affected by the interaction between planting methods and onion cultivars, in both seasons. The highest combination the two factors in respect to TSS % was obtained when using ridges method and Giza Red cultivar, while the highest one for dry matter % was obtained when using raised bed methods and Giza 6 Mohassn cultivar, in both seasons. Planting onion seedlings on flat land and using Giza 6 Mohassan cultivar appeared the lowest values of TSS % in the two seasons and of dry matter % in the first season. Planting of onion seedlings on flat land and using Giza Red cultivar appeared the lowest values of dry matter % in the second seasons.

Water productivity (WP):

Water productivity (WP), calculated by dividing the bulb yield by the total amount of water applied for different treatments and presented in Table 9. Results indicate that (WP) values were, in the first season, improved under planting on raised bed (P_3) by 42.75 and 20.56 % more than under planting on flat land (P_1) and ridges 60 cm (P_2), respectively, In the 2nd season the corresponding values reached to 43.99 and 20.73%. The highest WP values for P_3 could be due to the small amount of applied water and increase in onion bulb yield for P_3 as compared with the P_1 and P_2 treatments.

Giza Red (C_3) onion cultivar gave the highest values of WP, i.e., 8.94 and 9.31 kg bulb/m^3 water applied in the two seasons, respectively.

Regarding the effect of interaction, data presented in Table (9) indicate that Giza Red (C_3) and planting on raised bed (P_3) gave the highest value of WP in the two successive seasons, of bulb yield, i.e., 10.81 and 11.02 kg/m^3, respectively. While, Giza-6 (C_1) and planting on flat land (P_1) gave the lowest value of WUE, i.e. 6.61 and 6.28 kg/m^3 in the two seasons, respectively.

Water use efficiency (WUE):

Results in Table (9) reveal that the overall mean values of WUE, as a function of planting methods were 8.34, 10.01 and 11.60 kg bulbs/m^3 water consumed in the two successive seasons. Planting onion on raised bed 120 cm width (P_3) gave the highest WUE values, i.e., 11.65 and 11.55 kg bulbs/m^3 water consumed in first and second seasons, respectively. The lowest WUE values, i.e. 8.21 and 8.47 kg bulbs/m^3 water consumed in the two successive seasons were observed from planting on flat land (P_1). These results may be due to that planting on raised bed 120 cm width (P_3) gave the highest bulbs yield and the lowest CU, but planting on flat land (P_1) decreased bulb yield by 13.26 and 11.60% in both seasons, while the CU values increased by 23.40 and 20.28% in the same two seasons (Tables, 4 and 7).

Table (9): Effect of planting methods on water productivity and water use efficiency for three onion cultivars in 2013/2014 and 2014/2015 seasons.

Planting method (P)	Cultivars (C)	WP (kg/m^3) First season	WP (kg/m^3) Second season	WP (kg/m^3) Overall mean	WUE (kg/m^3) First season	WUE (kg/m^3) Second season	WUE (kg/m^3) Overall mean
P_1	C_1	6.61	6.28	6.45	7.70	7.45	7.58
	C_2	6.79	7.42	7.11	8.27	8.75	8.51
	C_3	7.29	7.77	7.53	8.65	9.22	8.94
Mean		6.90	7.16	7.03	8.21	8.47	8.34
P_2	C_1	7.69	7.74	7.72	9.22	9.22	9.22
	C_2	8.10	8.72	8.41	9.91	10.20	10.06
	C_3	8.73	9.15	8.94	10.65	10.85	10.75
Mean		8.17	8.54	8.36	9.93	10.09	10.01
P_3	C_1	8.78	9.72	9.25	10.33	10.93	10.63
	C_2	9.96	10.19	10.08	11.89	11.24	11.57
	C_3	10.81	11.02	10.92	12.74	12.47	12.61
Mean		9.85	10.31	10.08	11.65	11.55	11.60
Mean of cultivars	C_1	7.69	7.91	7.81	9.08	9.20	9.14
	C_2	8.28	8.78	8.53	10.02	10.06	10.05
	C_3	8.94	9.31	9.14	10.68	10.85	10.77

(P_1, P_2 and P_3 planting methods: Planting on flat land (traditional), ridges (60 cm) and raised bed (120 cm); (C_1, C_2 and C_3) Cultivars: Giza 6 Mohassan, Giza 20 and Giza Red, respectively

Considering onion cultivars, the results indicate that, Giza Red (C_3) gave the highest WUE averages, i.e. 10.68 and 10.85 kg bulbs/m^3 water consumed in the two seasons, respectively. However, the lowest values, i.e. 9.08 and 9.20 kg bulbs/m^3 water consumed in the two successive seasons were detected from Giza 6 Mohassan. Giza 20 decreased WUE values by 6.18 and 7.28% in both seasons, respectively, than Giza Red cultivar. These results may referred to the reduction in bulbs yield/fed and the reduction in CU values for Giza 6 Mohassan and Giza 20, compared with Giza Red. On the other hand, data reveal that onion cultivar Giza 6 Mohassan resulted in lower WUE values comprised 14.98 and 15.21% less than those Giza Red, respectively, in 2013/2014 and 2014/2015 seasons.

Regarding the effect of interaction, data presented in Table (9) reveal that planting raised bed 120 cm width (P_3) and Giza Red (C_3) gave the highest productivity of water unit, i.e. 12.74 and 12.47 kg bulbs/m^3 water consumed in 2013/2014 and 2014/2015 seasons, respectively. Whereas, planting on flat land (P_1) and Giza 6 Mohassan gave the lowest values of water unit productivity, i.e. 7.70 and 7.45 kg bulbs/m^3 water consumed in the two successive seasons.

Storability

Data in Table (10) reveal that, in general, under the adopted planting methods the lower values of bulb weight losses % were obtained under P_3 after two, four and six months storage periods in the two successive seasons. These results are in line with those obtained by **Shock *et al.* (1998)** who found a substantial increase of decomposition in onion during storage with increasing irrigation. In this sense, **Satyendra *et al.* (2007)** stated that irrigation at 0.80 Ep resulted to minimum physiological loss in weight% for onion during 60 days of storage, while extended storage period, decreasing irrigation (0.60 Ep) had adverse effect on storability of the onion bulbs. These variations may be attributed to the difference in assessed planting methods and/or onion cultivars besides prevailing weather conditions during the storage periods. **Rabbani *et al.* (1986)** reported that storage losses in onion could be as high as 66% due to many factors, such as cultivars, bulb maturity, moisture content of the bulb, temperature, relative humidity, etc.

Regardless planting methods, the onion cultivars showed a significant effect to alter onion bulb weight losses % due to the adopted storage periods. Data in Table (10) illustrate that the lower values of weight bulb losses% were exhibited by Giza 6 mohassan cultivar, comparable with Giza 20 and Giza red onion ones, respectively, in two growing seasons.

Table (10): Weight losses percentage after 2, 4 and 6 months as affected by planting methods on some onion cultivars in 2013/2014 and 2014/2015 seasons.

Planting method (P)	Cultivars (C)	Weight losses (%) after					
		First season			Second season		
		Two months	Four months	Six months	Two months	Four months	Six months
P_1	C_1	5.53	11.92	40.58	5.49	11.86	40.93
	C_2	7.10	14.08	47.42	6.39	12.39	42.56
	C_3	11.27	16.68	50.66	10.82	14.68	50.41
Mean		7.97	14.23	46.22	7.57	12.98	44.63
P_2	C_1	4.25	9.34	37.56	3.71	9.34	36.25
	C_2	5.26	10.40	42.16	4.90	10.38	40.76
	C_3	6.87	14.67	43.40	5.87	13.49	47.99
Mean		5.46	11.47	41.04	4.83	11.07	41.67
P_3	C_1	3.18	7.73	31.39	3.36	8.45	33.46
	C_2	4.83	8.12	33.61	3.74	8.95	35.27
	C_3	4.99	13.18	39.39	5.21	12.59	41.02
Mean		4.33	9.68	34.80	4.10	10.00	36.58
Mean of cultivars	C_1	4.32	9.66	36.51	4.19	9.88	36.88
	C_2	5.73	10.87	41.06	5.01	10.57	39.53
	C_3	7.71	14.84	44.48	7.30	13.59	46.47
L.S.D at 5 %	(P)	0.53	2.73	2.94	0.83	1.42	5.14
	(C)	0.85	1.77	2.98	0.75	1.46	3.64
	(P X C)	1.47	3.07	5.16	1.30	2.52	6.31

(P_1, P_2 and P_3 planting methods: Planting on flat land (traditional), ridges (60 cm) and raised bed (120 cm); (C_1, C_2 and C_3) Cultivars: Giza 6 Mohassan, Giza 20 and Giza Red, respectively

The interaction effects of the adopted treatments on onion bulb storability were almost significant under the different storage periods in the two successive seasons. Generally, the lower values of weight bulb losses% were recorded due to planting Giza 6 Mohassan on raised bed method.

CONCLUSION

It could be concluded that planting onion on raised bed (120 cm) with Giza red cultiver improved the water productivity and yield of onion.

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تحسين المحصول والقدرة التخزينية وإنتاجية المياه لبعض أصناف البصل من خلال طرق زراعة مختلفة

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أقيمت تجربة حقلية خلال موسمي 2014/2013 ، 2015/2014 بمحطة البحوث الزراعية بسدس – بنى سويف بهدف دراسة تأثير طرق زراعة البصل في (أرض مستوية ، خطوط بعرض 60 سم ، مصاطب بعرض 120 سم) على الإنتاجية والقدرة التخزينية وكذالك العلاقات المائية لثلاثة أصناف من البصل (جيزة 6 محسن ، جيزة 20 ، جيزة أحمر) واستخدم في ذلك تصميم القطع المنشقة مره واحدة في أربعة مكررات وكانت أهم النتائج المتحصل عليها كما يلي:

- تحت ظروف الزراعة على مصاطب (120 سم) انخفضت كميات المياه المضافة والاستهلاك المائي الموسمي مقارنة بالزراعة في الأرض المستوية وعلى خطوط لجميع الأصناف في كلا الموسمين.
- كانت أعلي متوسطات لارتفاع النبات ، عدد الأوراق علي النبات ، طول البصلة ، وعدد الأيام حتى النضج ونسبة المواد الصلبة الذائبة في كلا الموسمين قد نتجت من زراعة البصل علي خطوط بعرض 60 سم ، بينما الزراعة علي مصاطب سجلت أعلى المتوسطات لكل من قطر البصلة ، وزن النبات ، النسبة المئوية للمادة الجافة لجميع الأصناف تحت الدراسة في الموسمين.
- زاد المحصول القابل للتسويق والمحصول الكلى ووزن البصلة تحت ظروف الزراعة على مصاطب بالمقارنة بالزراعة في الأرض المستوية وعلى خطوط ، وكانت أقل قيم لمحصول الأبصال النقضة (المحصول الغير قابل للتسويق) تحت ظروف الزراعة في الأرض المستوية لجميع الأصناف في كلا الموسمين.
- تحسنت كل من إنتاجية المياه وكفاءة استعمالها تحت ظروف الزراعة على مصاطب إذا قورنت بالزراعة في الأرض المستوية وعلى خطوط لجميع الأصناف في كلا الموسمين.
- أظهرت معاملة زراعة البصل على مصاطب بعرض 120 سم نقصا معنويا في النسبة المئوية للفقد في وزن الأبصال في مختلف فترات التخزين في كلا الموسمين.

تحت ظروف منطقة الدراسة يمكن التوصية بزراعة البصل (صنف جيزة أحمر) على مصاطب بعرض 120 سم الحصول على اعلي محصول وتحسين العائد من وحدة المياه المضافة والمستهلكة .