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Article

Efficacy of irrigation intervals and chemical weed control on optimizing bulb yield and quality of onion (*Allium cepa* L.)

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ABSTRACT: Two field experiments were carried out at the village ten, Abu Humus, El-Beheira Governorate, Egypt, during the two successive seasons 2016/2017 and 2017/2018, to evaluate the effect of three types of herbicide and three irrigation intervals on productivity and quality of onion cultivar (Giza Red). The experiments were designed as split plot in randomized complete block design with three replications. Irrigation intervals – (I_1) 20 days, (I_2) 30 days, and (I_3) 40 days – were assigned to the main plots. Herbicides treatments – (H_1) Control, (H_2) Fluazifop-p, (H_3) Oxyfluorfen, and (H_4) Clethodium – were distributed randomly in sub-plots. The results revealed that the interaction between herbicide and irrigation intervals had significant effects on productivity and quality of onion (Giza Red) cultivar in both seasons. Maximum onion bulbs yield (14.06 and 14.29 ton/fed) was recorded at (I_3 with H_3) treatments in first and second seasons, respectively. (I_2 with H_3) led to increase onion harvest index values. The highest value of carbohydrates percentage and total soluble solids (TSS) obtained at {I_3 and H_2}. Herbicides residues in dry onions bulbs under all treatments were found well below the maximum residue limit set by World Health Organization (WHO)/Food and Agriculture Organization (FAO) (0.05 mg/kg). In conclusion, the interaction of Oxyfluorfen herbicide and irrigation interval 40 days could be used to improve fresh and dry bulb yield (ton/fed) of onion cultivar, harvest index and water use efficiency (WUE). The treatment of {I_3 (40 days) with H_2 (Fluazifop-p)} could be used to enhance bulb diameter (cm) after harvest, TSS and the percentage of carbohydrates.

Key words: herbicides, irrigation regime, productivity, onion, herbicides residues. water use efficiency.

INTRODUCTION

Onion (*Allium cepa* L.), family of Alliaceae (green or dry), is one of the most important crops and it has high economic values for both local and export market in Egypt. Onion cultivation production can be harmed by abiotic and biotic stresses (Ghodke et al. 2018).

Unlike most crops, onion has very poor competitive ability with weeds due to its inherent characteristics, such as shallow root system, narrow leaf and small leaf area index, and slow plant development (Sahoo et al. 2017). Weeds are one of the main problems in onion fields. Competitive of weeds with onion fields is not only for growth factors, but also as hosts of insects and fungal diseases, which lead to reduce the final yield of onion. The yield of onion cultivars can be reduced by 26-48% due to the weed competition (Rai and Meena 2017). For controlling the weeds effects, the chemical weed control should be used as an alternative method to save the optimal yield. Chemical weed control such as oxyfluorfen, pendimethalin, and metribuzin were used to decrease and prevent weed populations and to increase onion yields (Ahuja and Sandhu 2003). Weeds dry matter was significantly reduced due to application of pendimethalin, metolachlor, oxyfluorfen either alone or in combination with hand weeding at 35 days after planting compared to weedy check in onion (Kolhe 2001). Chemical weed control as herbicides has been used as the major control tool for the last decades in developed countries, but herbicides have a negative impact on the environment. Public concerns due to these negative side effects have led to political action plans to reduce herbicide use. These considerations are taken to a large geographic scale, and also political pressure requires to think about the use of herbicides and to promote integrated weed management systems. Efficacy of herbicides reduced on plants under water stress. Under drought a 25 to 50 percent increase in the application rate of herbicides may be required to achieve weed control comparable to that achieved under moist conditions (Kidder and Behrens 1988).

The limited available water resource is a major challenge in the arid and semi-arid regions especially in the agricultural sector, which uses the most amounts of water resources (Ward and Pulido-Velazquez 2008), and food demands require efficient water use and high yield (Ali 2017). Water conservation will help to ensure the future of sustainable agriculture and the environment. Water scarcity has negative impact in plant growth in many parts of the world. Numerous studies have been conducted in various countries to promote the utilization of water in the agricultural sector. Because of its shallow and sparse roots, onion is susceptible to water shortages which originates from inadequate irrigation frequency caused by insufficient irrigation frequency and waterlogging, which can affect the water use efficiency (Wakchaure et al. 2018). The amount of water affects yield and quality of onion (Piri and Naserin 2020). Onion yields are highly sensitive to irrigation deficiency (Rao 2016), and, when the soil moisture content below field capacity, it causes yield reduction (Bekele and Tilahun 2007). Water use efficiency is defined as the ratio of dry-matter accumulation or final yield to water consumption over a season. Increasing water use efficiency could affect plant growth. When water is limited, the productivity of plants that use a finite water supply more efficiently would be positively affected.

Therefore, the objectives of this study were to evaluate the interaction effect between three types of herbicide and three irrigation intervals on productivity and quality of onion cultivar (Giza Red) using surface flood irrigation; and to find out the optimal irrigation water regime and best herbicides treatment which could be used to improve productivity and quality of onion cultivar with the herbicides residues under the optimum permissible limit.

MATERIALS AND METHODS

Experimental site and treatments

Two field experiments were carried out at the village ten, Abu Humus, El-Beheira Governorate, Egypt (Latitude: N31°10’01.7”, Longitude: E 30°22’21.3”), which is characterized by a semi-arid climate with moderate cold winters and warm summers during the two growing seasons 2016/2017 and 2017/2018. The three types of herbicide were used as given in Table 1 with three irrigation intervals (20, 30, and 40 days) using surface flood irrigation Giza Red cultivar. Onion Giza Red cultivar seedlings of good quality were transplanted in first December and harvest in April 20 in both seasons. The experiments were designed as split plot in randomized complete block design with three replications.

Table 1. Herbicides tested for weed control in onion during the 2016/2017 and 2017/2018 growing season.

Commercial name	Chemical name	Chemical group
Select	Clethodium	Cyclohexanedione
Fusilade	Fluazifop-p	Aryloxyphenoxy propionate
Goal	Oxyfluorfen	Diphenylether

Irrigation intervals – (I_1) 20 days, (I_2) 30 days and (I_3) 40 days – were assigned to the main plots, herbicides treatments as pre-planting and at 35 days after transplanting (DAT). (H_1) control, (H_2) fluazifop-p, (H_3) oxyfluorfen, and (H_4) clethodium were distributed randomly in sub-plots. Area of subplot was 21 m^2 (7 m long × 3 m width). Onion transplanted in the plot with a spacing of 25 × 10 cm and intensity of crop were 168,000 plant/fed. Application of fertilization and chemical control in both seasons were applied as recommended in the region according to Bulletin No. 982 (2005).

The Food and Agriculture Organization (FAO) Penman–Monteith method (Allen et al. 1998) was used to calculate the reference evapotranspiration ETo in the CROPWAT Program. Crop water requirements (ETc) through both growing season were determined from the reference evapotranspiration (ETo) and crop coefficient (Kc) by the Eq. 1:

$$ETc = Kc * ETo \tag{1}$$

The soil and water analyzed are shown in Tables 2 and 3.

Table 2. Physical and chemical properties for the soil experimental sites in 2016/2017 and 2017/2018.

Seasons	Physical properties			Chemical properties					
	Sand%	Silt%	Clay%	pH	Ec (ds/m^{-1})	Caco$_3$%	Available (ppm)		
							N ppm	P ppm	K ppm
2016/2017	2.5	1.26	96.24	7.79	3.6	3.9	9.2	5.9	3.6
2017/2018	2.48	1.27	96.25	7.78	3.54	3.8	9.3	5.7	3.67

Table 3. Water analysis for the water experimental sites in both seasons.

pH	Ec ds m	Ca	Mg^{++}	K^{+}	Na	Hco^{-3}	So^{4}
7.3	0.48	2.3	1.5	0.05	1.9	2.4	1.8

Yield attributes

Onion bulbs yield (ton/fed) was measured from each subplot after manual harvesting of crop at physiological maturity, dry onion bulbs yield (ton/fed) after 20 days from harvest, and harvest index was calculated according to Sharma and Smith (1987), based on the Eq. 2:

$$\text{Harvest index} = \text{bulb yield} / \text{biomass yield (straw weight + bulbs weight)} \times 100 \tag{2}$$

Bulb quality parameters estimation

Bulb diameter (cm), and total soluble solids (TSS °Brix) were determined in juice of bulb onion with a hand refractometer in the same representative sample of bulbs at harvest, and carbohydrate total percentage content in onion sample was estimated according to Sarkiyayi and Agar (2010) at Principal Central Lab, Faculty of Agriculture, Cairo University.

Residues of herbicides in onion bulbs

QuEChERS method for determination the herbicides residues in onion bulbs (MRL) using LC-MSMS, GC-MSMS (European Standard Method EN 15662 2008) was used. The measurement uncertainly expressed as expanded uncertainly (at 95% level of confidence) is within range ± ($p < 0.05$), chromatography (HPLC), at Center Laboratory of Residue Analysis of herbicides and in onion, Agricultural Research Center, Ministry of Agriculture.

Water use efficiency

Water use efficiency (WUE) was calculated according to Droorenbos and Pruitt (1977) (Eq. 3):

$$\text{WUE for bulb yield} = \text{bulb yield (Kg/Fad)} / \text{irrigation water applied (m}^3\text{/Fed)} \tag{3}$$

Statistical analysis

Data were subjected to the statistical analysis of variance according to the method mentioned by Snedecor and Cochran (1980). Significance of difference among means was compared using least significant differences (LSD) including F-test, at $p < 0.05$ level. This statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) (v. 12.0, SPSS Inc., Chicago, IL, United States of America).

RESULTS AND DISCUSSION

Fresh and dry onion bulb yield (ton/fed)

Irrigation intervals and herbicides treatments had significant effects on onion bulb yield (ton/fed) in both seasons (Table 4). Regarding to irrigation intervals, I_1 (20 days) recorded the maximum onion bulb yield in both seasons (10.62 and 10.6 ton/fed). The amount of irrigation water used has a significant impact on onion yield. It was highly sensitive to water in the root zone soil, which was according with results from similar studies (Piri and Naserin 2020). Concerning the herbicides effect, H_3 (oxyfluorfen) significantly boosted onion yield when compared to other herbicides and achieved the maximum onion bulb yield in both seasons (13.5 and 13.63 ton/fed), while the minimum onion bulb yield in both seasons was recorded with H_1 (control). Due to increased weed competition, the transplanted onion yield was reduced due to weeds growth. These results are in conformity with the observations of Saini and Walia (2012), who found that plots treated with oxyfluorfen had higher fresh bulb weight, and Loken and Hatterman-Valenti (2010), who reported that uncontrolled weed growth caused 49-86 percent reduction in bulb yield compared with the best herbicidal treatment. The interaction effect between herbicide and irrigation intervals had significant effect on onion bulb yield (ton/fed) in both seasons.

I_3 (40 days) with H_3 (oxyfluorfen) gave the maximum onion bulb yield (ton)/fed (14.06 and 14.29 ton/fed) in both seasons, while the minimum onion bulb yield was recorded (ton)/fed with {I_2 (30 days) H1 (control)} treatment. Irrigation intervals, herbicides, and their interaction had significant effects on dry onion bulb yield (ton/fed) in both seasons (Table 4). H_3 (oxyfluorfen) recorded the maximum dry onion bulb yield (ton/fed) at 20 days after harvest (9.856 and 13.440 ton/fed) in both seasons, while the minimum values (3.085 and 3.813 ton/fed) in both seasons were obtained by H_1 (control).

About irrigation intervals, data indicated that I_2 (30 days) led to obtain the maximum value (7.448 and 10.136 ton/fed) of dry onion bulb yield in both seasons, while the lowest values (7.280 and 9.50 ton/fed) in both seasons were produced by I_3 (40 days). The interaction of I_3 (40 days) and H_3 (oxyfluorfen) gave the maximum dry onion bulb yield.

Table 4. The effect of irrigation intervals and herbicides on fresh and dry onion bulb yield (ton/fed) during 2016/2017 and 2017/2018 growing seasons.

Fresh onion bulb yield (ton/fed)									
2016/2017					2017/2018				
Treatment	I_1	I_2	1_3	Mean	Treatment	I_1	I_2	1_3	Mean
H_1	4.99	4.2	4.86	4.68	H_1	5.012	4.13	4.98	4.7
H_2	12.6	10.98	10.37	11.31	H_2	12.76	10.86	10.19	11.27
H_3	12.57	13.89	14.06	13.5	H_3	12.34	14.28	14.29	13.63
H_4	12.32	11.88	8.4	10.86	H_4	12.3	12.65	8.42	11.12
Mean	10.62	10.23	9.42	10.08	Mean	10.6	10.48	9.47	10.18
	LSD ($p < 0.05$) of I			0.07		LSD ($p < 0.05$) of I			0.18
	LSD ($p < 0.05$) of H			0.14		LSD ($p < 0.05$) of H			0.15
	LSD ($p < 0.05$) of I × H			0.44		LSD ($p < 0.05$) of I × H			0.47

continue...

Table 4. Continuation...

Dry onion bulb yield (ton/fed)									
2016/2017					2017/2018				
Treatment	I_1	I_2	1_3	Mean	Treatment	I_1	I_2	1_3	Mean
H_1	3.085	3.276	2.940	3.085	H_1	3.141	3.304	4.989	3.813
H_2	9.296	7.924	7.756	8.288	H_2	12.768	10.472	10.864	11.368
H_3	8.848	10.360	10.416	9.856	H_3	12.348	14.280	14.840	13.440
H_4	8.680	8.904	6.160	7.840	H_4	12.292	12.656	8.428	11.088
Mean	7.448	7.616	6.720	7.280	Mean	10.136	10.136	9.632	9.500
	LSD ($p < 0.05$) of I			0.224		LSD ($p < 0.05$) of I			0.122
	LSD ($p < 0.05$) of H			0.168		LSD ($p < 0.05$) of H			0.224
	LSD ($p < 0.05$) of I × H			0.560		LSD ($p < 0.05$) of I × H			0.672

LSD: least significant difference; I: irrigation intervals; H: herbicides treatments.

Harvest index

Irrigation intervals had significant effects on the harvest index (Table 5). I_3 (40 days) recorded the maximum onion harvest index, and application of {I_1 (20 days)} produced the minimum harvest index in both seasons. The lowest water supply resulted in higher bulbing ratio (Serhat and Çigdem 2009, Metwally 2011). The data revealed that using H_2 (fluazifop-p) significantly resulted in maximum onion harvest index in the first season, while in second season it was obtained by H_3 (oxyfluorfen). The interaction effect of herbicides and irrigation intervals had significant effects on harvest index in both seasons. The data indicate that I_2 (30 days) with H_3 (oxyfluorfen) led to increase onion harvest index values in both seasons.

Table 5. The effect of irrigation intervals and herbicides on harvest index during 2016/2017 and 2017/2018 growing seasons.

2016/2017					2017/2018				
Treatment	I_1	I_2	1_3	Mean	Treatment	I_1	I_2	1_3	Mean
H_1	0.76	0.67	0.75	0.73	H_1	0.43	0.42	0.50	0.45
H_2	0.81	0.76	0.81	0.79	H_2	0.59	0.56	0.58	0.58
H_3	0.74	0.86	0.76	0.78	H_3	0.59	0.66	0.56	0.60
H_4	0.76	0.74	0.75	0.75	H_4	0.53	0.54	0.58	0.55
Mean	0.77	0.76	0.76	0.76	Mean	0.53	0.54	0.55	0.54
	LSD ($p < 0.05$) of I			0.11		LSD ($p < 0.05$) of I			0.6
	LSD ($p < 0.05$) of H			0.08		LSD ($p < 0.05$) of H			0.1
	LSD ($p < 0.05$) of I × H			0.26		LSD ($p < 0.05$) of I × H			0.32

LSD: least significant difference; I: irrigation intervals; H: herbicides treatments.

Bulb quality

Bulb diameter after harvest

Bulb diameter (cm) was significantly affected by both irrigation intervals and herbicides (Table 6). No significant differences between I_2 (30 days) and I_3 (40 days) both achieved the largest onion bulb diameter, and application of H_2 (fluazifop-p) herbicide recorded the maximum average of onion bulb diameter in both seasons. Bulb diameter, bulb volume, bulb weight and bulb yield were found to be high in weed free (Rahman et al. 2011) and fluazifop-p was able to control all types of weed flora more efficiently than other herbicides. The control plot recorded the lowest bulb diameters than all the treatments, because the treatment had the highest weed competition. Unweeded onion plots had lower bulb diameter and yield (Patel et al. 2011). The interaction effect of herbicides and irrigation intervals had significant effect on bulb diameter in both seasons, and I_3 (40 days) with H_2 (fluazifop-p) gave the largest diameter. Onion bulb diameter affected by water deficits (Piri and Naserin 2020), and weeds compete with onions for light, nutrients, water, and space and they significantly reduced bulb size and onion yield (Qasem 2005, Rai and Meena 2017).

Table 6. The effect of irrigation intervals and herbicides on bulb diameter (cm) after harvest during 2016/2017 and 2017/2018 growing seasons.

2016/2017					2017/2018				
Treatment	I_1	I_2	1_3	Mean	Treatment	I_1	I_2	1_3	Mean
H_1	3	4.2	3	3.4	H_1	3	2.9	2.9	2.9
H_2	6.8	7.4	7.6	7.2	H_2	5.5	5.2	5.8	5.5
H_3	6.4	6.7	6.7	6.6	H_3	5.6	5.4	5.3	5.4
H_4	5.8	5.9	4.3	5.3	H_4	4.3	4.7	4.5	4.5
Mean	5.66	6	5.4	5.6	Mean	4.6	4.55	4.6	4.57
LSD ($p < 0.05$) of I				0.56	LSD ($p < 0.05$) of I				0.81
LSD ($p < 0.05$) of H				0.87	LSD ($p < 0.05$) of H				0.68
LSD ($p < 0.05$) of I × H				2.6	LSD ($p < 0.05$) of I × H				2

LSD: least significant difference; I: irrigation intervals; H: herbicides treatments.

Total soluble solids

Results in Table 7 showed that the different irrigation intervals and herbicides treatments had significant effects on onion TSS in both seasons. I_3 (40 days) recorded the maximum onion TSS (12.5 and 11.8 °Brix) in the first and the second season, respectively. TSS increased under stress conditions usually due to the stress on carbohydrates synthesis mechanism in the leaves and subsequent translocation to the bulbs (Hamilton et al. 1998). Under stress, a faster rate of starch conversion to sugars could also lead to TSS fluctuations (Wakchaure et al. 2018). Under stress, a faster rate of starch conversion to sugars could also lead to TSS fluctuations. Regarding to herbicides effects, H_3 (oxyfluorfen) resulted in maximum TSS. On the contrary, the minimum average onion bulb TSS in both seasons were recorded by H_1 (control). The interaction between herbicide and irrigation intervals had significant effects on TSS in both seasons, and I_3 (40 days) with H_2 (fluazifop-p)} was produced maximum TSS in both seasons, in harmony with those obtained by Rai and Meena (2017), who reported that the weed-free treatment recorded significantly maximum bulb TSS.

Table 7. The effect of irrigation intervals and herbicides on the percentage of total soluble solids (TSS °Brix) during 2016/2017 and 2017/2018 growing seasons.

2016/2017					2017/2018				
Treatment	I_1	I_2	1_3	Mean	Treatment	I_1	I_2	1_3	Mean
H_1	6.2	8.8	11.8	8.9	H_1	7.5	10.4	11.9	9.9
H_2	14.1	12	14.6	13.5	H_2	10.9	10.2	13.3	11.4
H_3	6.4	9.4	13.3	9.7	H_3	12.6	13	10.6	12
H_4	14.3	7	10.6	10.6	H_4	9.9	11.7	11.7	11.1
Mean	10.25	9.3	12.5	12.5	Mean	10.25	11.3	11.8	11.1
LSD ($p < 0.05$) of I				0.51	LSD ($p < 0.05$) of I				0.39
LSD ($p < 0.05$) of H				0.16	LSD ($p < 0.05$) of H				0.32
LSD ($p < 0.05$) of I × H				0.5	LSD ($p < 0.05$) of I × H				0.97

LSD: least significant difference; I: irrigation intervals; H: herbicides treatments.

The percentage of carbohydrates (%)

The statistical analysis of the data showed that the percentage of carbohydrates (%) was significantly affected by irrigation intervals, herbicides, and their interaction (Table 8). H_3 (oxyfluorfen) herbicide increased total carbohydrate content and led to produce the maximum ratio of carbohydrates. On the contrary, H_1 (control) recorded the lowest percentage of carbohydrates. Irrigation interval treatment I_1 (20 days) increased the percentage of carbohydrates comparing to the other irrigation treatments. The treatment of {I_3 (40 days) with H_2 (fluazifop-p)} recorded the highest percentage of carbohydrates in both seasons (88.82 and 87.86%), while the highest irrigation interval I_3 (40 days) without herbicide led to produce the minimum percentage of carbohydrates (76.16 and 75.8%). Regular irrigation intervals promoted plant growth by increasing photosynthesis levels and the total carbohydrate percentage (Bhasker et al. 2018).

Table 8. The effect of irrigation intervals and herbicides on the percentage of carbohydrates during 2016/2017 and 2017/2018 growing seasons.

2016/2017					2017/2018				
Treatment	I_1	I_2	1_3	Mean	Treatment	I_1	I_2	1_3	Mean
H_1	77.16	76.42	76.16	76.58	H_1	77.18	76.21	75.8	76.39
H_2	87.45	86.25	88.82	87.5	H_2	88.47	86.47	87.86	87.6
H_3	89.54	87.79	87.21	88.18	H_3	89.2	86.8	87.21	87.7
H_4	86.8	87.14	88.28	87.4	H_4	86.01	86.8	87.39	87.7
Mean	85.2	84.4	85.11	84.9	Mean	85.2	84.04	84.5	84.6
	LSD ($p < 0.05$) of I			0.29		LSD ($p < 0.05$) of I			0.16
	LSD ($p < 0.05$) of H			0.33		LSD ($p < 0.05$) of H			0.38
	LSD ($p < 0.05$) of I × H			0.99		LSD ($p < 0.05$) of I × H			1.15

LSD: least significant difference; I: irrigation intervals; H: herbicides treatments.

Residues of herbicides in dry onions bulbs

Herbicide residues in dry onions bulbs samples under all treatments were found well below the maximum residue limit set by the World Health Organization (WHO)/Food and Agriculture Organization (FAO) (0.05 $mg{\cdot}kg^{-1}$).

Water use efficiency

Application of irrigation intervals had significant effects on WUE. I_3 (40 days) recorded the maximum WUE, while the application of I_1 (20 days) produced the minimum WUE. Because of its shallow and sparse roots, onion is susceptible to water shortages originated from inadequate irrigation frequency caused by insufficient irrigation frequency and waterlogging, which can affect the WUE (Piri and Naserin 2020). Onion plants can produce bulbs with less water, but not high quality (Zheng et al. 2013) and up to 23% reduction in water use efficiency for onion grown under deficit irrigation treatments (Wakchaure et al. 2018). Water use efficiency was higher in application of H_3 (oxyfluorfen) herbicide. The interaction between herbicides and irrigation intervals had significant effects on WUE in both seasons (Table 9), and treatment of {(I_3 (40days) with H_3 (oxyfluorfen)} increased WUE.

Table 9. The effect of irrigation intervals and herbicides on water use efficiency (kg/m3) during 2016/2017 and 2017/2018 growing seasons.

2016/2017					2017/2018				
Treatment	**I_1**	**I_2**	**1_3**	**Mean**	**Treatment**	**I_1**	**I_2**	**1_3**	**Mean**
H_1	1.18	1.4	2.02	1.5	H_1	1.2	1.4	2	1.53
H_2	3	3.6	4.3	3.7	H_2	2.9	3.56	4.45	3.6
H_3	2.9	4.6	5.8	4.43	H_3	3	4.67	6.1	4.59
H_4	2.9	3.9	3.5	3.43	H_4	3	3.9	3.61	3.5
Mean	2.49	3.37	3.9	3.2	Mean	2.5	3.38	4.04	3.3
LSD ($p < 0.05$) of I				0.2	LSD ($p < 0.05$) of I				0.56
LSD ($p < 0.05$) of H				0.14	LSD ($p < 0.05$) of H				0.42
LSD ($p < 0.05$) of I × H				0.42	LSD ($p < 0.05$) of I × H				1.27

LSD: least significant difference; I: irrigation intervals; H: herbicides treatments.

CONCLUSION

In this study, the interaction effect between three types of herbicide and three irrigation intervals on productivity and quality of onion cultivar (Giza Red) using surface flood irrigation was evaluated to select the best irrigation regime and the best herbicides treatment which could be used to improve productivity and quality of onion cultivar with the herbicides residues under the optimum permissible limit.

The results showed that the interaction between herbicide and irrigation intervals had significant effects on productivity and quality of onion.

The oxyfluorfen herbicide with irrigation interval of 40 days could be used to improve fresh and dry bulb yield (ton/fed) of onion cultivar, harvest index and WUE.

The treatment of {I_3 (40days) with H_2 (fluazifop-p)} could be used to enhance bulb diameter (cm) after harvest, TSS, and the percentage of carbohydrates.

Herbicides residues in dry onions bulbs samples under all treatments were found well below the maximum residue limit set by WHO/FAO (0.05 mg·kg^{-1}).

AUTHORS' CONTRIBUTION

Conceptualization: Ibrahim, H. H., Abdalla, A. A. and Salem, W. S.; **Methodology:** Ibrahim, H. H. and Abdalla, A. A.; **Investigation:** Ibrahim, H. H., Abdalla, A. A. and Salem, W. S.; **Original Draft:** Ibrahim, H. H., Abdalla, A. A. and Salem, W. S.; **Writing – Review and Editing:** Ibrahim, H. H. and Abdalla, A. A.; **Funding Acquisition:** Ibrahim, H. H., Abdalla, A. A. and Salem, W. S.; **Resources:** Ibrahim, H. H., Abdalla, A. A. and Salem, W. S.

DATA AVAILABILITY STATEMENT

All dataset were generated and analyzed in the current study.

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