Critical Period of Weed Competition in Onion (*Allium cepa* L.) in Jordan

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ABSTRACT

The effect of different weed competition and weed-free periods on growth and yield of onion and weeds was investigated in two field experiments carried out at the University of Jordan Campus, Al-Jubeiha and at Jordan University Research Station located at the central Jordan Valley, during 1996/1997 growing season. Results showed that the longer the period that onion kept weed free or the earlier those weeds were removed from the crop after transplanting, the higher the onion growth and bulb yield obtained. The highest yield was obtained from the weed-free plots for the entire growing season. While no yield was obtained from weed-infested crop for the whole growing season at the Jordan Valley, bulb yield reduction was 86% in the same treatment at the University Campus experiment. Bulb yield was not significantly changed at 14 to 49 days of weed-infested crop at both locations. While none of the weed-free periods gave similar yield to that of the weed-free control in the Jordan Valley, weed-clean crop for only three weeks after transplanting at the University Campus location significantly increased bulb yield over the weed-infested control. In the Jordan Valley, weed competition for 14 days after transplanting significantly reduced bulb dry yield compared with the weed-free control. Results showed that weed growth and development was much higher than that of onion plants especially under irrigation. Based on the dry bulb yield obtained, critical period of weed competition was at 50 days after onion transplanting at both locations. This however, depends on the competing weed species, their densities and growing of onion under irrigation or rainfed conditions.

KEYWORDS: Competition, critical period, onion, weeds**.**

INTRODUCTION

Different workers emphasized the poor competition of onion plants especially at early growth stages (Bleasdale, 1959; Wicks et al., 1973; Menges and Tamez, 1981; Garcia et al., 1994), and therefore this crop must be maintained weed free for a long period to avoid yield reduction (Glaze, 1987). Losses due to weed competition could be severe; Babiker and Ahmed (1986) reported 26-48% yield reduction in transplanted onion and Labrada (1977) reported 54%. Bulb yield loss increased with competition duration and maximum loss (94.7%) occurred due to full season competition (Rameshwar et al., 2001). Prakash et al. (2000) reported that season-long crop-weed competition reduced bulb yield by 81.2% compared with the weed-free condition.

The critical period of weed competition was defined as the period after crop emergence or planting at which weeds must be removed for non-significant yield loss (Nieto et al., 1968). However, this period depends on the competing crop and weed species, their densities, and agricultural operations. In onions, Shadbolt and Holm (1956) found that at 40-220 Amaranthus retroflexus plants/m^2 this period occurs in the first 4 weeks after emergence, and they reported 90% yield reductions at

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longer competition period at low as well as at high weed densities. Williams et al. (1973) reported that *Amaranthus retroflexus* interference at any time during growth reduced onion yields, while Wicks et al. (1973) reported that control of *A. retroflexus* in onion should be carried out at 4-10 weeks after planting. However, other workers reported different critical periods of weed competition in onion. Putnam et al. (1978) found the period occurs between 3-4 weeks in seeded onion at density of *Portulaca oleracea* between 50 to 450 plant m^{-2}. It was at 6-10 weeks with *Sisymbrium irio* (Menges and Tamez, 1981), and 6-8 weeks (Hewson and Roberts, 1973), or 6-20 weeks (Johnston et al., 1969) after the emergence of mixed weed population, and 20-30 days after the planting of onion infested with *Cyperus rotundus* (Purwito, 1978). Bhan et al. (1976) reported that weed-free onion for 45 days after planting significantly increased bulb yield over a weedy control treatment. In a mixed population of *S. irio* and *Helianthus annuus*, onion yield was reduced when this weed population interfered for 7 weeks after emergence (Labrada, 1977). However, Thomas and Wright (1984) found that onion susceptibility to weed competition occurs between 2-10 weeks after 50% emergence, and the authors expected a photoperiodic basis for onset of the critical period. In another study, Menges and Tamez (1981) found that *Euphorbia glyptosperma* did not significantly interfere with onion.

Rameshwar et al. (2001) reported that the highest onion bulb and onion yield contributing characters were obtained in plots remained weed-free for the first 60 days after transplanting. Competition between onion plants and weeds begins at emergence, but as the duration of competition increases, onion yield and onion bulb diameter were decreased compared to the weed-free onions. Onions weedy plots resulted in the lowest marketable yield (Vanhala, 1998). A strong correlation was found between onion yield and the duration of weed infestation period (Gazdag-Torma, 1997). Kizilkaya et al. (2001) concluded that weeds cause serious losses to onion bulb yield and quality and therefore must be controlled at 4-5 weeks after emergence. Weed competition during the whole crop cycle reduced bulb yield by 86%. Competition in the first 90 days after transplanting was comparable to that for the whole crop cycle while competition for the first 15 days had no adverse effect on yield. In another study, Shuaib (2001) reported that crop kept weed-free for the first 15 days only, resulted in 81% reduction in the bulb yield and therefore, the critical period of weed competition occurred from 15 to 45 days after transplanting. Onion plant height was greatest in plots kept weed-free for 50 days after emergence (Abdul Ghafoor et al., 2000). In a field study carried out to compare 16 weed control methods in onions (cv. Red Creole), Bhattarai (1998) reported that greatest yield and monetary returns to labor inputs were found in plots with monthly weeding for 4 months after transplanting and weeding twice (at the 2nd and 3rd month after transplanting). The economic threshold of weed competition was reported to occur from 61 to 74 days after transplanting, during which time the crop must be kept weed free in order to maximize bulb yields. Compared to the weed-free control, bulb yield reduction was least in the plots kept weed-free up to 60 days after transplanting, but weed infested plots up to harvest resulted in a 70% yield reduction. Results indicated that the critical period of onion-weed competition is between 36 and 48 days after transplanting (Gaffer et al., 1993).

The objective of this research was to study the competition effect of weeds on growth and yield of transplanted onion grown at two locations; the Jordan Valley and Al-Jubeiha, and to determine the critical period of weed competition in this crop under different field conditions at both sites.

MATERIALS AND METHODS

Two experiments were carried out, the first was at the Agricultural Research Station of the University of Jordan located at 255 m below the sea level in the central Jordan Valley, and the second was at the University Research

Station at the Jordan University Campus, located at Al-Jubeiha at an elevation of 980 m and of average annual rainfall of 450 mm. The soil in the Jordan Valley is sandy-loam of 50% sand, 25% silt and 25% clay with 1.3% organic matter and of a pH approximately 7.6. At Al-Jubeiha, the soil is clay-loam containing 62.3% clay, 36.7% silt, 1.1% sand, 0.7% organic matter and of a pH approximately 7.4.

The land in both locations was tilled twice. In the Jordan Valley, farm animal manure was applied over the entire experimental area at a rate of 1 ton ha^{-1}. The land in both locations was leveled and rows were made. Forty five-day old seedlings (2 and a half leaf stage) of onion cv. Geza 20, were hand transplanted on the 18th of November, 1996 in the Jordan Valley site, and at one week later at Al-Jubeiha location. Plot size was 3 by 1.5 m consisted of three rows. Planting distance was 10 cm between seedlings and 35 cm between rows and onion seedlings were planted on both sides of the row.

NPK (18:18:9) fertilizer was applied over the entire experimental area in both locations at a rate of 130 kg ha^{-1}, and urea (46% N) at a rate of 68 kg ha^{-1} on December 2nd and 23rd at the Jordan Valley location for both types of fertilizers, respectively, and on December 7th and 26th, 1996 at Al-Jubeiha site and for the two fertilizers, respectively. Urea was re-applied at 100 kg ha^{-1} on the 20th of January, 1997 in both locations and DAP (di-ammonium phosphate) fertilizer at a rate of 100 kg ha^{-1} (for both experiments) on the 16th of February, 1997 and 1st of March, 1997 for both the Jordan Valley and Al-Jubeiha locations, respectively.

In both experiments, weeds were allowed to compete with onion plants for 0, 14, 21, 28, 35, 42 and 49 days after transplanting, then removed and plots were kept weed free until harvest. In other plots, weeds were continuously hand-weeded and kept weed free for similar periods after onion transplanting after which weeds were left to grow until harvest. Weed removal treatments were started on 9 December 1996 and 31 December 1996 in the Jordan Valley and Al-Jubeiha locations, respectively.

In the Jordan Valley experiment, plots were sprinkler irrigated using 4 sprinklers placed 6 m apart from each other with a discharge of 0.6 m^3 h^{-1} per sprinkler. Irrigation was carried out for three hrs twice a week (except during the rainy season) with a total delivery of sprinklers per experimental area of 14.4 m^3.

At Al-Jubeiha location, plants were frequently irrigated using a hose with a rose attached for 3-4 weeks after transplanting then onion was left to grow under rainfed conditions until harvest.

Crop maturity was assessed on the bases of the fall-over of the onion canopy, and then onion was harvested on 15 May 1997 at the Jordan Valley and on 8 June 1997 at Al-Jubeiha site. In both experiments, onion bulbs were carefully lifted from the soil using a small hand- hoe.

Data on total onion plants fresh weight, bulb fresh and dry weights, bulbs number and diameter, vegetative fresh and dry weights, leaf number and on weed fresh and dry weights were recorded.

In both experiments, treatments were laid out in a randomized complete block design with four replicates. Data were statistically analyzed by the Analysis of Variance (ANOVA), and means were compared using the Least Significant Differences (LSD) at P = 0.05.

RESULTS

Weed species found at both locations and their densities are shown in Table (1).

EXPERIMENT 1 (JORDAN VALLEY)

Effect on Onion

The effect of weed competition on onion growth and yield is shown in Table (2). All growth parameters of onion were reduced when weeds were allowed to compete with onion, and the effect increased with weed competition period from 14 to 49 days after transplanting. The greatest reduction in total onion yield was obtained when weeds were allowed to compete for the entire growing season. Reduction in bulb yield was complete.

Extending the weed-free duration after onion transplanting significantly increased onion growth

parameters and bulb yield over the weed infested control, although differences in weed-free treatments between 14 to 42 days after transplanting were not significant. The longer the period that onion remained weed free, the higher the growth and yield obtained. However, the lowest onion yield was found when weeds were not removed throughout the whole growing season or when onion was left weed free for only the first 14 days after transplanting. Fresh bulb yield of onion kept weed free for up to 35 days after planting and weed-infested control were not significant.

Considering both weed-infested and weed-free periods, it appears that differences in onion growth and yield were not greatly varied at periods from 14 to 49 days after transplanting in spite of the increase in onion yield with longer weed-free periods or yield reduction at longer competition periods.

Bulb fresh and dry yield, diameter, number and onion total yield and shoot weight were all negatively affected by weed competition. Weed-free for the whole growing season was the best for onion growth and yield although differences between treatments and weed infested control were not significant.

Effect on Weeds

The effect of weed competition and weed free treatments on weed growth is shown in Table (2). Weed fresh and dry weights were increased with weeds allowed to compete with onion crop for long periods after transplanting. The highest weed biomass obtained was when weeds competed with onions for the whole growing season or when onion kept weed free for only 14 days after transplanting. In contrast, the lowest weed growth was found when weeds were removed shortly after crop transplanting. However, the changes in weed dry weight at periods between 14 to 35 days after onion transplanting were not significant. Results clearly demonstrated that weed-free periods for 42 to 49 days after onion transplanting reduced growth and competition effect of the subsequently emerged weeds and significantly increased onion growth and yield compared with other weed-free periods.

EXPERIMENT 2 (JUBEIHA)

Effect on Onion

Weed competition longer than 28 days after onion transplanting impaired all growth parameters and bulb yield of onion compared with the weed-free control (Table 3). Weeds competed with onion for the whole growing season resulted in 87% of bulb yield reduction. Differences in crop growth and yield at weed-competition periods from 28-49 days were not significant.

Onion remained weed-free for up to 49 days after transplanting failed to produce yield comparable to the weed-free crop. Onion growth and yield were significantly reduced with shorter weed-free periods that crop kept weed free after transplanting. Onion kept weed free up to 49 days after transplanting produced 46% of dry bulb yield compared with the weed-free control. Both bulb number and diameter were increased with extended weed free period.

However, it appears that two peaks of weed competition were found at 42 and 50 days after onion transplanting at Al-Jubeiha site. This may be considered the critical period at which weeds must be removed to avoid any significant yield losses (Figure 2).

Effect on Weeds

The greatest weed growth in terms of shoot dry weight was obtained when weeds competed with crop plants for the whole growing season (Table 3). Shoot dry weight of weeds significantly increased with extending weed-infested period. Results showed that the shorter the period that crop remained weed-free after transplanting, the greater the growth of weeds, with weed shoot fresh and dry weights at 14 days after transplanting were almost comparable to those of the weed-infested control.

Results showed that weeds emerged later in the growing season had better chance to accumulate more dry matter compared with weeds emerged early in the

growing season. Results indicated that more fresh weight was needed to produce a unit of dry matter of weeds in weed-infested treatments compared with that required to produce the same unit in weed-free treatments indicating that competition was mainly for water at early growth stages and weed growth was almost doubled at periods from 21 to 35 days after transplanting. In contrast, crop plants did not show similar growth pattern at the same growth intervals.

Critical Period of Weed Competition

Considering the effect of both weed-infested and weed-free periods on onion dry bulb yield, the critical period of weed competition in onion was found to occur at 50 days after transplanting at the University Research Station and at the Jordan Valley site (Figures 1 and 2). Weeds had no significant effect on onion yield provided that they were removed by any means at this period at both locations. Based on the average dry bulb yield of onion at both sites, the critical period of weed competition was found to occur at 50 days after transplanting (Figure 3).

DISCUSSION

Weeds compete with crop plants for growth factors and impair crops growth and productivity. However, crops as well as weeds are different in their competition effects and therefore weed competition periods can be varied accordingly and influenced by other factors such as agricultural practices (Zimdahl, 1980). It is well established that onions in general are weak competitors with weeds and suffer rapidly in competition (Bleasdale, 1959; Wicks et al., 1973; Menges and Tamez, 1981; Karim et al., 1998). The competition effect, even for a short period after onion emergence, can harm crops and may result in severe yield losses and growth reduction which is in most cases unrecoverable and can't be overcome by the addition of higher levels of growth factors mainly water and nutrients (Williams et al., 1973; Zimdahl, 1980). It is well documented that factors such as short stature, low above ground canopy, slow growth and very shallow and small root system all contributed in the weakness that onions show in competition. However, since weed population is rarely pure under field condition, but instead different weed species may form weed populations once at a time. Therefore, one of the main factors that affect weed competition periods is weed population composition, species relative densities and their spatial arrangements. In our studies at the two locations, results clearly demonstrated that complete loss of onion growth and yield is possible as a result of weed competition for the entire growing season (Tables 2 and 3). Other workers reported similar findings (Prakash et al., 2000; Rameshwar et al., 2001). Competition effect may be more serious under irrigation in the Jordan Valley which may be due to available optimum conditions for weed growth during competition cycle especially water, nutrients and suitable temperature. In the Jordan Valley, weed population however, is a composite of different species dominated by broadleaf weeds in the presence of certain narrow species that compliment each other in their competition influence on onion crop. Results indicated that the longer the weed competition period, the higher the reduction in onion growth and yield with the lowest yield obtained from weed-infested plots for the entire growing season (Tables 2 and 3). However, weed removal for only two weeks after planting was not enough to significantly increase onion yield over the weed-infested control (Tables 2 and 3). This seems logic since crop plants require more available water and nutrients to start rapid growth early in the season, while this was not possible in the presence of dense weed population of composite species shortly after emergence (Table 1). Therefore, weed competition for few weeks early in the season is serious and onion growth and yield loss may be unrecoverable if weeds were allowed to compete at early stages after planting. Struggle between weeds and crop plants early after weed emergence is strong, since dense weed population could normally appear early in the season and individuals tend to capture

as much as possible from resources to insure growth and survival. Although differences in growth factors available or provided at both locations in terms of water, nutrients and even light are wide enough, and similar differences in weed population composition and density in both sites were also evident but critical period was found similar in both locations (Figures 1 and 2). It appears that growth of both weeds and onion was slow at Al-Jubeiha location due to cool weather conditions during winter season and therefore weed growth was not greatly changed at the period from 14 to 49 days after planting (Table 3) and this was not reflected as differences in dry bulb yield of onion at the same period. In contrast, weeds at the Jordan Valley location showed high growth at 4 weeks after crop transplanting at which their shoot fresh and dry weights doubled at 14 or 21 days period. However, changes in weed dry weight obtained at weed-free period from 21 to 49 days after transplanting was marginal. Location effect on onion yield was expected because onion growth and yield were normally higher under the Jordan Valley conditions than under rainfed conditions at Al-Jubeiha location. It appears that water and nutrient favored weeds over onion at the Jordan Valley location and therefore weed control is an important measure to be taken for full use of these resources by crop plants and for high onion yield. It is well established that the addition of more resources may favor weeds over crop plants and weeds respond better than their associated crops for more supply of these growth factors (Qasem, 1987) and many weed species tend to accumulate higher amounts of nutrients than crops they compete with under field conditions (Qasem, 1992).

It can be concluded that weeds are a serious threat to onion crop under Jordan conditions and can lead to complete crop failure. More reduction in onion growth and yield may be resulted under favorable growth conditions in the presence of weeds while weeds have an advantage with more available resources and can attain higher growth. The critical period of weed competition was clearly determined at two locations of different weed populations, and geographical and climatic conditions and found to occur at 50 days after onion transplanting which agreed with the findings of different researchers in different parts of the world (Johnston et al., 1969; Hewson and Roberts, 1973, Labrada, 1977; Menges and Tamez, 1981). However, this period is usually varied within or between regions depending on weed species, their densities, spatial arrangement and distribution, crop cultivars and competitiveness, agricultural practices and climatic conditions (Qasem, 2003).

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Table (1). Weed species and their average densities at all removal intervals found in onion experiments during the 1996/1997 growing season.

Weed species	Density (Plant m^{-2})
Jordan Valley Location	
Chenopodium murale L.	210
Malva sylvestris L.	85
Echinochloa colonum (L.) Link.	36
Sisymbrium irio L.	3
Sonchus oleraceous L.	1
Beta vulgaris L.	1
Anthemis sp.	1

Al-Jubeiha Location	
Avena sterilis L.	42
Anthemis cotula L.	20
Sinapis arvensis L.	10
Vicia narbonensis L.	6
Lamium amplexicaula L.	6
Erodium cicutarium (L.) L'Her	3
Convolvulus arvensis L.	2
Gallium sp.	1
Ranunculus arvensis L.	1
Medicago sativa L.	1
Cirsium arvense (L.) Scop.	1
Cynodon dactylon (L.) Pers.	1

Table (2). Effect of weed competition at different periods on onion yield at the Jordan Valley site during the 1996/1997 growing season.

Period after transplanting (days)	ONION						WEEDS	
	Total fresh weight (kg ha^{-1})	Fresh bulb weight (kg ha^{-1})	Dry bulb weight (kg ha^{-1})	Bulb diameter (cm)	Bulb no. per ha (X 1000)	Shoot dry weight (kg ha^{-1})	Fresh weight (ton ha^{-1})	Dry weight (ton ha^{-1})
WEED-INFESTED								
14	20096	16956	13696	3.77	242	1096	9.1	0.9
21	17822	15144	12033	3.90	180	740	8.9	1.2
28	15011	13100	9367	3.36	182	700	15.8	2.7
35	16751	14044	10878	3.44	211	856	28.3	3.0
42	14928	13022	9211	3.45	196	707	33.8	4.6
49	15040	12822	9720	3.45	173	700	38.8	5.4
Whole season	0	0	0	0	0	0	20.8	16.1
WEED-FREE								
14	3051	2224	1976	2.38	10	251	16.0	13.6
21	8111	7256	5429	2.41	169	400	13.3	10.7
28	9478	8411	5420	2.49	216	644	10.7	8.1
35	9000	6956	5428	2.67	189	533	14.4	10.6
42	9889	7944	6084	2.73	189	584	12.2	9.4
49	11807	8578	6667	2.64	191	629	12.7	7.4
Whole season	18596	15611	14307	3.64	276	922	-	-
LSD (P = 0.05)	8827	7612	6481	1.03	72	333	9.6	3.1

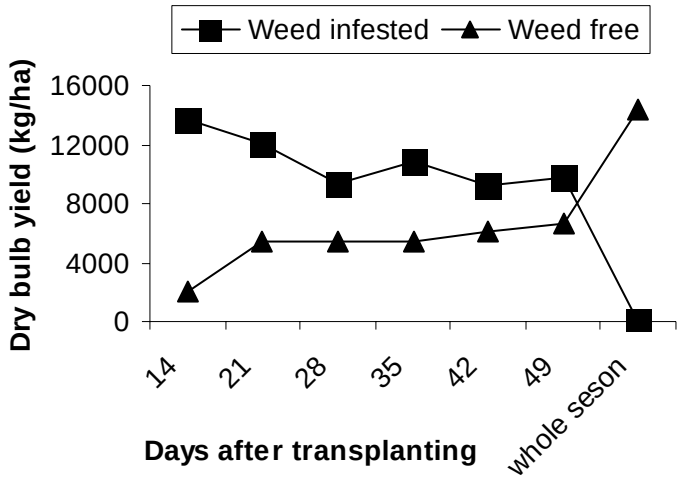

Fig.1. Critical period of weed competition in onion grown in the Jordan Valley. Curves based on onion dry bulbs weight

Table (3). Effect of weed competition at different periods on onion yield at Al-Jubeiha site during the 1996/1997 growing season.

Period after transplanting (days)	ONION						WEEDS	
	Total fresh weight (kg ha^{-1})	Fresh bulb weight (kg ha^{-1})	Dry bulb weight (kg ha^{-1})	Bulb diameter (cm)	Bulb no. per ha (X 1000)	Shoot dry weight (kg ha^{-1})	Fresh weight (ton ha^{-1})	Dry weight (ton ha^{-1})
WEED-INFESTED								
14	13198	10642	9792	3.32	275	688	0.62	0.15
21	12777	9919	8896	2.75	238	708	1.83	0.51
28	13823	10558	9583	3.00	260	646	1.32	0.19
35	10717	8673	8052	2.22	285	621	1.56	0.39
42	11052	7917	7392	2.52	323	673	1.10	0.38
49	11792	8281	7366	2.17	304	642	1.20	0.35
Whole season	1685	1533	1406	1.33	125	152	22.56	7.06
WEED-FREE								
14	6192	5360	3979	2.39	163	363	15.10	5.07
21	7860	6615	5788	2.32	219	465	7.46	2.42
28	10121	8590	6625	2.65	269	475	9.17	3.04
35	9967	8563	6177	2.60	194	405	10.62	3.39
42	10567	9110	7183	2.57	225	417	6.75	1.65
49	9735	8125	6708	2.61	208	444	3.80	0.31
Whole season	15344	11708	10602	3.18	269	615	-	-
LSD (P = 0.05)	3688	3019	2674	0.57	88	244	5.40	1.72

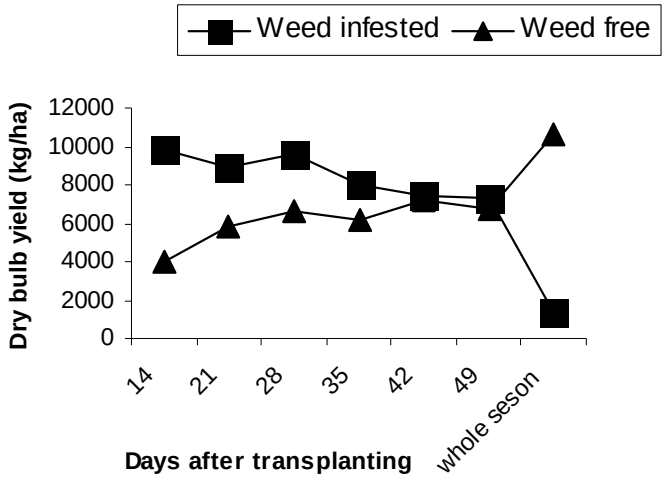

Fig. 2. Critical period of weed competition in onion grown at Al-Jubeiha location. Curves based on onion dry bulb weight

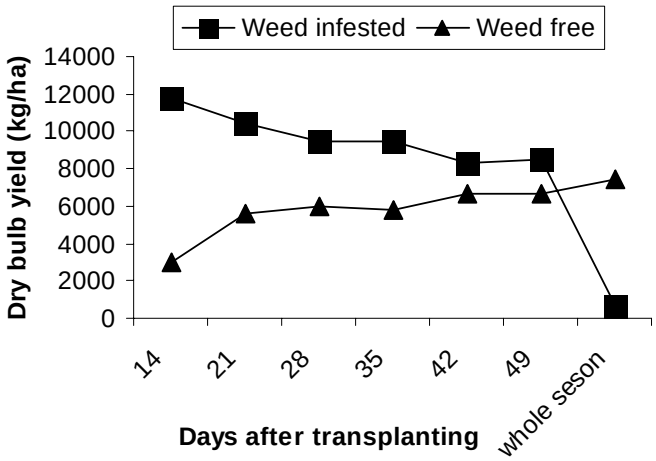

Fig. 3. Onion dry bulb yields, when onion allowed remaining weedy for different periods then kept clean for different periods and the weeds then allowed to develop. Curves based on data from two locations in Jordan

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الفترة الحرجة لمنافسة الأعشاب في محصول البصل (*Allium cepa* L.) في الأردن

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ملخـص

تمت دراسة تأثيرات المنافسة للأعشاب الضارة على نمو وإنتاج محصول البصل في الأردن وذلك من خلال تجربتين حقليتين تم إجراؤهما في موقعين مختلفين هما غور الأردن (تحت ظروف الري) وموقع الجبيهة (تحت الظروف المطرية) وذلك خلال موسم النمو لعام 1997/1996م. أظهرت نتائج التجارب التي أجريت على العلاقات التنافسية بين البصل والأعشاب وكذلك لتحديد الفترة الحرجة لمنافسة الأعشاب في هذا المحصول أنه كلما طالت الفترة التي بقي المحصول خلالها نظيفا من الأعشاب أو كلما أزيلت الأعشاب مبكرا من محصول البصل بعد زراعته أمكن الحصول على نمو كبير لنباتات البصل وإنتاج أفضل من الأبصال. لقد تم الحصول على أعلى إنتاج من الأبصال من المقاطع التي بقيت نظيفة من الأعشاب طوال موسم النمو بينما وصل الخفض في الإنتاج إلى 86% في موقع الجبيهة والى 100% في منطقة الغور عندما تركت الأعشاب تنافس المحصول طوال فصل النمو وذلك مقارنة بمعاملة الشاهد النظيف من الأعشاب. ففي حين لم تؤد أي من معاملات إزالة الأعشاب على فترات إلى الحصول على إنتاج من الأبصال الجافة مشابه لإنتاج الشاهد النظيف من الأعشاب طوال فصل النمو في موقع غور الأردن، أدى ترك المحصول نظيفا من الأعشاب لمدة أسبوعين فقط بعد الزراعة في منطقة الجبيهة إلى زيادة ذات قيمة إحصائية في إنتاج البصل مقارنة بمعاملة الشاهد المبوء بالأعشاب حتى نهاية موسم النمو. إن منافسة الأعشاب لمدة أسبوعين فقط بعد الزراعة كانت كافية لاحداث خفض في إنتاج البصل تحت ظروف غور الأردن مقارنة بالشاهد النظيف من الأعشاب. أظهرت النتائج أن نمو ومنافسة الأعشاب كانا أكبر من مثيليهما لنباتات البصل خاصة تحت ظروف الري في غور الأردن. وباعتماد الإنتاج الجاف للأبصال، فإن الفترة الحرجة لمنافسة الأعشاب في محصول البصل هي حوالي خمسين يوما بعد الزراعة في كلا الموقعين.

الكلمات الدالة: منافسة، فترة حرجة، أعشاب، بصل.

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