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Reaction of Some Southern Iranian Onion Ecotypes to Translocation

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ABSTRACT

Onion originated in Iran and its neighboring countries. Dependent on climatic conditions, this crop is cultivated in the Southern region of Iran during spring or autumn. Most onions are short day cultivars. In order to elucidate the characteristics of these South Iranian cultivars, a field experiment was conducted at Shahid Chamran University in Autumn, 2002. In this experiment, 12 cultivars ('Ramhormozy', 'B1', 'Ghermaz Azarshahar', 'Daaman', 'P80', 'Shahdad', 'Bardseer', 'Sarkareh', 'Primavera', 'Texas Yellow Grano', 'Texas Early Grano', 'G1'), which are cultivated in southern regions, were sown under a randomized block design with three replications. During growth and development different morphology characteristics, viz. plant height, number of leaves per plant, bulb diameter, neck diameter, bolting percentage, average bulb yield, weight and number of storage leaves of different cultivars were recorded. Maximum plant height was recorded for 'Ghermaz Azarshahar' cultivar 16 days after emergence. This cultivar exhibited earlier and more uniform emergence than others. However 'Primavera' dominated all other characteristics under study during the transplanting stage of growth, but was equated by 'P80' in some characteristics. The effect of stress brought about by transplanting impeded the growth of seedlings for a month. After transplanting stress, the leaf area exhibited a 100 to 200% increase daily in March with the onset of optimum growth conditions from 10 February, to 20 March. Concerning photoperiod sensitivity of cultivars leaf and leaf area production rate decreased from 21 March to 10 April. The reaction of non-native plant cultivars was inconsistent. Some of them produced a floral stem and seed, while others produced a bulb. Maximum and minimum yields were recorded for 'G1' and 'Primavera', respectively. Among early maturing varieties 'P80' produced the maximum number of bulbs.

Keywords: *Allium cepa*, dormancy, photoperiod

INTRODUCTION

Iran and its neighboring countries are known as the origin of onion (*Allium cepa*) in the world (Hanelt 1990). This means that maximum genetic variation is found in this region. Production of bulbs or stalks depends on cultivar, temperature, photoperiod, and the interaction between these effects (Brewster 1994; Ansari 2000; Cheema *et al*. 2003). Perhaps for this reason, each onion cultivar has been adapted to a specific region. Onion cultivars in Iran have differences in their morphological and physiological characters (Azimi *et al*. 2000). Even intra-cultivar differences exist increasingly manifested during different weather conditions (Ansari 1997). Bulb production occurs in long photoperiods, but the reaction of cultivars to photoperiod differs (Garner and Allard 1920). Formation of the stalk is needed for seed production. Stalk formation follows bulb vernalization of young seedling. Onion seed is sown in autumn for bulb production in spring or for seed production in tropical and sub-tropical regions. Early cultivation of seedling in these regions may result in bolting in spring (Ansari *et al*. 2000). This is because onion seedlings tend to grow in autumn and a period two months of exposure to cold weather in these regions, or late cultivation increases the threat of serious reduction in yield since in these regions, after passing a cold period, plant growth is seriously reduced after exposure to hot weather. Therefore one of the important objectives of onion production in the world is the breeding of onion cultivars that are resistant to bolting (Ansari *et al*. 2000; Hu 2003).

Onion is a strategic plant in Iran. Previous experiments in Ahwaz determined that onion seed produced at Shahid Chamran University Ahwaz from cultivars 'P80', 'B1', 'G1', and 'Ramhormozy' have better characteristics such as early maturation ('P80' and 'G1'), resistance to bolting ('P80' and 'G1'), and moderate shelf life ('Ramhormozy' and 'B1'), some of them being sensitive to pests such as thrips, onion fly ('G1'), and diseases such as downy mildew (*Peronospora destructor*) and black mold (*Aspergillus nigra*) ('G1') (Ansari 2002). Although some native cultivars are tolerant to pests and diseases such as onion fly and black mold ('Ramhormozy' and 'P80'), in Iran there is an attempt to produce better cultivars and propagate more variation.

To determine the required photoperiod for bulb production, a single cultivar can be sown on a certain date, after a period of growth and development (6-9 months), and then the production or non-production of bulbs can be judged. Even though experiments were conducted in a specified place with a certain day length, the number of bulbs produced and the maturation of various cultivars differed (Magruder *et al*. 1941). In separate experiments, a number of bulbing or bolting plants differed according to cultivar and were characterized by differences in stalk length, flowering time and required cold period for stalk production; these characters were often compared with standard cultivars (Brewster 1994).

New cultivar character evaluation against standard cultivar characters includes: resistance or sensitivity to main local diseases such as *Fusarium oxysporum*, downy mildew (*Peronospora destructor*) and black mold (*Aspergillus nigra*), pests such as onion thrips (*Thrips tabaci* Lind.), onion maggot (*Delia antiqua* Meigen), and environmental stresses such as low and high temperature, and water stress (Arvin and Banakar 2002; Baniameri *et al*. 2003; McDonald *et al*. 2003; Roos and Fouver 2005). Onion cultivars are classified into short, intermediate, and long-day types based

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on photoperiod (Magruder and Allard 1937). This is the minimum photoperiod that onion bulb requires for its formation. This classification has more application for bulb production and onion cultivar improvement in various latitudes; usually short day onion cultivars are grown at less than 30° latitude, intermediate between 30° and 38°, and grown at latitudes greater than 38° are long-day types (Tarakanov and Mamadu 1990; Rubatzky and Yamaguchi 1997). The idea is that both the bulbing and the bolting of the plant are controlled by the balance between hormones. One of main external stimulators of hormones production of bulb formation is photoperiod, therefore with increasing photoperiod, bulb formation rate will be faster. And with decreasing photoperiod, bulb formation rate will decrease (Brewster 1994). If a cultivar is not sensitive to photoperiod induction in a region, it will not be suitable for bulb production in that region. For example, if a long day or a moderate cultivar is sown near the equator, it never produces bulbs. Therefore, because required photoperiod is never prepared for stimulation of bulb production, it does not form a real bulb. In addition, if a short day onion cultivar is sown at great latitudes during spring, the effect of long day length on leaves results in the rapid reception of photoperiod signals which then stimulate bulb production by phytochrome; consequently, small and weak plants having only two or three leaves were stimulated to induce bulbs, resulting in the rapid production of very small bulbs (Currah and Proctor 1990; Ansari 1997; Mettananda 2003).

Onion bulb maturation depends on the management practices in the field; moreover, maturation time differs from year to year. Differences occur over various years due to heat accumulation in seasonal growth and development. Other practices such as date sowing, seedling transplanting time, accumulation of dry matter in leaves and bulbs affect the leaf area, all of which affect bulb maturation time (Mondal *et al*. 1986; Brewster 1990; Hu *et al*. 2003).

A good cultivar must have a visually attractive bulb to consumers, resistance to diseases and pests, have a high yield, uniform shape, color, maturation time, and long shelf life, and also produce good seed. The most important purpose of the present research is to allow readers to be acquainted with the growth reactions of some important onion ecotypes cultivated south of Iran in Ahwaz conditions (Ahwaz has subtropical weather; autumn and winter are temperate but by the beginning spring the weather becomes warmer so that at the end of the harvesting period it already over 40˚C).

MATERIALS AND METHODS

This experiment included 12 cultivars in a complete randomized block design with three replications. These cultivars included: 'Ghermaz Azarshahar' from Azerbaijan province, five other native varieties from southern provinces of Iran ('Bardseer' and 'Shahdad' from Kerman, 'Sarkareh' from Booshehr, 'Ramhormozy' from Khouzestan, 'Daaman' from Seestan-Balouchestan); three lines ready to be released from Shahid Chamran University as new varieties ('P80', 'G1', Bh1 selected from Behbahan); and three foreign varieties which are being cultivated in southern areas of Iran, i.e. 'Texas Early Grano', 'Texas Yellow Grano', and 'Primavera'. Except for samples of Shahid Chameran University and foreign varieties, others were received from the gene bank of Karaj, Iran.

This experiment was conducted at the Department of Horticulture, Faculty of Agriculture, Shahid Chamran University. According to acquired analysis, the type of soil was determined to be loam. The area of each experiment was 2.5 m^2, and each replication had 5 lines. The distance between lines was 45 cm and the distance between any two plants in the line was 8 cm. In this experiment seedlings were used for cultivation. Each line had 32 plants. Seedlings were transplanted to the main field 70 days after emergence in the nursery. All practices were similar for all cultivars in both nursery and field. Sampling began from the 16th day of plant emergence, and was repeated at 40, 67, 96, 126, 150, 164, and 184 days after emergence. Final harvesting occurred from the 3rd and 4th lines after having eliminated the front and back ends (50 cm) of cultivation lines. Samples were taken to the lab where bulb and neck diameter, plant and green leaf height, leaf area, leaf fresh and dry matter and bulb weight were measured, while the rate of bulbing was calculated by dividing bulb diameter by neck diameter. Paying close attention to maturation time of cultivars, bulbs were harvested at 3 stages from 6th May to 6th July. In the final harvest, the percentage bolting was calculated; furthermore it had been measured first. Thereafter, harvested bulbs were classified into three groups according to the number of bulbs: >5 cm, 3-5 cm and <3 cm.

Analysis of variance of data was measured based on a complete randomized block design using statistical software (Mstatc Version 1.42) and the means were compared using Duncan's multiple range test. Finally, cultivars were classified following an analysis using a complete linkage method. All variables had the same weighting, and thus the following formula was used: $d(x,y) = \sqrt{(x_1-y_1)^2+(x_2-y_2)^2+\ldots+(x_n-y_n)^2}$. Then, based on all data during the harvesting period, the classification was measured using another software (Statistica Version 5).

RESULTS AND DISCUSSION

Growth and development of plants

The height of onion plants 16 days after emergence was strongly cultivar-dependent. This phenomenon may be due to the speed of germination and emergence between 'Ghermaz Azarshahar' and other cultivars (Ansari 1997). 'Ghermaz Azarshahar' emerged at least two days earlier than all other cultivars and could, in many experiments, germinate earlier than the other cultivars. Although there were no significant statistical differences, 'G1' and 'P80' were shorter than 'Ghermaz Azarshahar'. However, some cultivars had many differences. 'Daman' was the shortest while there were no statistical differences at the 5% level between 'Daaman', 'Shahdad', 'Texas Early Grano' and 'Bardseer'.

Forty days after emergence, cultivar had less effect on height and leaf number of plants compared with 16 days after emergence; with particular attention to native cultivars, speed of growth was sometimes faster than non-native cultivars. Non-native cultivars had less leaves and were shorter than native cultivars. Sixty seven days after emerging, however revealed a significant difference ($P = 0.01$) in all measured characters except for leaf numbers. At this stage of growth, 'Primavera' had the best characteristics before transplanting than all other cultivars. 'Primavera' has been detected as an early cultivar ('P80') in Iran and statistically, some were not different. Minimum bulb diameter at this stage was in 'Ramhormozy' (**Table 1**). One month after plant transplanting, leaf numbers were mostly fixed or reduced caused by transplanting stress; i.e. growth stopped in this period. Fifty-five days after transplanting, differences between cultivars were more evident. Leaf area increased compared with transplanting time. At this stage 'Sarkareh' displayed maximum characters such as height, dry weight of plant, leaves, and bulb, neck diameter but whereas 'G1' had maximum fresh weight of leaves and bulbs. The growth of 'Sarkareh' began earlier than the other cultivars after transplanting; and could quickly compensate for the transplanting stress. At this stage of sampling leaf area of various cultivars significantly increased compared with the post 25 days later. The average increase in daily leaf area was 1-2 times. This rate of increase continued from the 20th February to 20th March. One hundred and fifty days after emerging, so that in a 24 day period, the speed in which leaf area increasing daily reduced, whereas leaf area increased 2-7-fold. One hundred and sixty-four days after emerging, differences between cultivars at the 1% level were significant for more measured characters. 'Ramhormozy' was taller than the other cultivars, but it did not differ from 'G1', 'Shahdad', 'Daaman', and 'Texas Early Grano'. Regarding fresh leaves, 'Daaman' had maximum weight but statistically there was no difference between 'Ghermaz Azarshahar', 'Shahdad', 'Ramhormozy', 'Bardseer' and 'G1'. At this

Table 1 Comparison of some characters of onion cultivars 67 days after emergence.

Cultivar	Bulb diameter (mm)	Neck diameter (mm)	Leaf area (cm^2)	Bulb dry weight (g)	Leaf dry weight (g)	Bulb fresh weight (g)	Leaf fresh weight (g)	Height (cm)	№ leaves
Texas Yellow Grano	5.0 bcd	3.6 abc	7.9 de	0.05 b	0.10 bcd	0.39 a	0.95 f	24.7 b	3.5 a
Sarkareh	7.6 cd	3.8 ab	14.7 b	0.05 b	0.20 b	0.46 b	2.32 b	32.5 cd	4.0 a
Ghermaz Azarshahar	5.0 bcd	3.3 abcd	9.1 cde	0.15 bb	0.12 bcd	0.31 b	1.16 def	23.2 b	3.5 a
Daaman	4.1 cd	2.5 d	7.3 e	0.02 b	0.07 cd	0.18 b	0.78 ef	21.3 cd	4.0 a
Shahdad	4.0 cd	2.3 d	7.4 de	0.01 b	0.05 d	0.18 b	0.99 ef	27.2 d	3.7 a
P80	6.7 ab	3.6 abc	14.1 bc	0.06 b	0.17 bc	0.46 b	1.99 bc	33.3 b	4.2 a
Texas Early Grano	4.1 cd	2.7 bcd	8.3 de	0.03 b	0.09 cd	0.27 b	0.99 ef	31.0 b	3.7 a
Ramhormozy	3.7 d	2.6 cd	8.6 de	0.02 b	0.10 bcd	0.20 b	1.14 def	33.3 b	3.7 a
Primavera	8.0 a	4.1 a	21.0 a	0.14 a	0.31 a	1.13 a	3.14 a	41.3 a	4.2 a
G1	4.2 cd	3.2 abcd	12.8 bcd	0.04 b	0.17 bc	0.39 b	1.48 bcd	32.2 b	3.5 a
B1	4.8 bcd	3.3 abcd	12.1 bcde	0.06 b	0.16 bc	0.44 b	1.79 bcde	28.8 bc	3.7 a
Bardseer	5.8 bc	3.7 abc	10.3 bcde	0.06 b	0.15 bcd	0.46 b	1.34 cdef	21.7 d	3.7 a

* Different letters within a column indicates a significant difference by Duncan's Multiple Range Test, P=0.05.

Table 2 Comparison of some characters of onion cultivars in186 days after emerging

Cultivar	Bulb diameter (cm)	Neck diameter (cm)	Leaf area (cm^2)	Bulb dry weight (g)	Leaf dry weight (g)	Bulb fresh weight (g)	Leaf fresh weight (g)	Height of green leaves (cm)	№ leaves	№ close scales	№ open scales
Texas Yellow Grano	4.9 bc	0.9 b	0 f	6.09 cd	1.01 c	73.7 cd	6.0 de	35.0 bc	2.00 gh	6.25 bc	2.75 c
Sarkareh	6.0 ab	1.8 ab	174.0 cd	15.40 abc	5.94 bc	96.3 abcd	46.3 bcde	51.2 abc	14.00 cd	11.50 a	5.25 b
Ghermaz Azarshahar	3.7 c	2.6 ab	362.2 a	5.62 cd	15.25 a	51.3 cd	157.1 a	67.5 a	20.00 b	0.00 d	11.75 a
Daaman	4.5 bc	1.9 ab	115.7 cdef	7.04 cd	4.45 bc	53.2 cd	62.3 bc	45.5 bc	9.75 de	5.00 c	7.00 abc
Shahdad	5.0 abc	2.3 ab	220.3 bc	11.02 bcd	9.50 b	61.1 cd	62.6 bc	55.2 abc	28.25 a	5.00 c	10.25 ab
P80	5.9 ab	0.8 b	14.0 ef	9.72 cd	1.15 c	82.8 bcd	7.3 de	0 d	3.00 fgh	9.50 ab	4.75 bc
Texas Early Grano	6.0 ab	1.2 b	130.4 cde	11.72 bcd	4.87 bc	112.2 abc	35.1 cde	53.7 abc	9.75 de	4.75 c	6.25 abc
Ramhormozy	7.2 a	1.3 b	97.3 def	21.22 a	5.88 bc	149.6 a	46.4 bcde	53.7 ab	10.25 de	6.25 bc	6.25 abc
Primavera	4.1 bc	0.5 b	3.0 f	2.75 d	0.35 c	35.8 d	2.3 e	0 d	0.00 h	5.25 c	7.75 abc
G1	6.1 ab	5.2 a	134.9 cde	20.05 ab	8.81 b	143.1 ab	49.6 bcd	47.0 bc	6.75 efg	6.50 bc	7.25 abc
B1	5.1 abc	0.9 b	86.2 def	9.00 cd	5.24 bc	59.0 cd	29.9 cde	44.0 bc	8.00 ef	5.00 c	6.00 abc
Bardseer	5.2 abc	1.9 ab	306.8 ab	9.01 cd	9.76 b	72.7 cd	83.3 b	62.0 ab	16.50 bc	7.00 bc	8.00 abc

* Different letters within a column indicates a significant difference by Duncan's Multiple Range Test, P=0.05.

Table 3 Bulb characteristics in different onion cultivars at harvesting time.

Cultivar	Total bulb yield /m^2 (g)	Bulbs with diameter 5 cm or greater		Bulbs with diameter 3-5 cm		Bulbs with diameter 3 cm		Percentage flowering
		%	Weight (g)	%	Weight (g)	%	Weight (g)	
Texas Yellow Grano	1970.6 e*	43 d	1230.3 f	30 a	490.3 a	27 a	250.0 ab	0 c
Sarkareh	2891.6 e	71 abc	2555.0 bcd	14 abcd	203.3 abc	15 abcde	133.3 abcd	53 a
Gharmez Azarshahar	2005.3 de	50 cd	1418.3 ef	21 abcd	351.0 abc	29 a	236.0 ab	65 a
Daaman	2735.3 de	71 abc	2354.6 bcde	7 de	134.1 abc	22 abc	246.6 ab	45 ab
Shahdad	2431.3 de	64 bcd	1968.0 cdef	17 abcd	283.3 abc	19 abcd	180.0 abcd	38 ab
Pary 80	3078.3 dc	87 ab	2884.6 b	10 bcd	172.1 abc	3 ed	21.6 cd	0 c
Texas Early Grano	2357.3 de	51cd	1785.3 def	24 abc	366.6 abc	25 ab	205.4 abc	0 c
Ramhormozy	3430.3 ab	85 ab	3162.0 ab	15 abcd	268.3 abc	0 e	0.0 d	0 c
Primavera	1935.0 e	42 d	1196.6 f	28 ab	473.3 ab	30 a	265.1 a	0 c
G1	3948.3 a	88 a	3783.3 a	6 d	105.0 c	6 bcde	60.0 bcd	3 c
Bh3	2826.6 cd	69 abc	2356.6 bcde	22 abcd	393.3 abc	9 bcdee	76.7 abcd	2 c
Barderseer	3062.6 bc	75 ab	2725.0 bc	12 abcd	217.6 abc	13 abcde	120.0 abcd	26 b
Average	2722.7	66.3	2284.9	17.2	288.2	16.5	149.6	19.3

* Different letters within a column indicates a significant difference by Duncan's Multiple Range Test, P=0.05.

stage of growth, 'P80' had maximum weight of the fresh bulb, but was not significantly different from 'Ramhormozy'. Also 'P80' had maximum bulb diameter, followed by 'Ramhormozy'. 'Primavera' and 'Daaman' had minimum and maximum neck diameter respectively, and the neck diameter of the onion bulb began to reduce at the time of maturation; and the greater the neck diameter of the bulb, the less the shelf life (Brewster 1994). On the other hand, the taller the bulb, the longer it is (shape-wise); but with a decrease in bulb height, bulbs become wider. At this stage 'Ramhormozy' and 'Sarkareh' were tallest and shortest, respectively. Maximum leaf area was observed in 'Shahdad', followed by 'Ghermaz Azarshahar', 'Daaman', 'P80', 'Ramhormozy' 'G1', and 'Bardseer'. Among the studied cultivars 'Ramhormozy' had largest green leaves. The most and least number of green leaves were formed by 'Shahdad' and 'Primavera', respectively. At this stage of growth, all characters of the leaf began to reduce in earlier cultivars ('Texas Yellow Grano', 'Primavera', 'Texas Early Grano', 'P80') although bulb diameter and bulb weight increased in these. On the contrary, non-native cultivars did not react to temperature changes and day length at this stage of growth, but all characters of leaves increased.

One hundred and eighty-six days after emerging, all measured characters of all cultivars had significant differences at the 1% level. 'Ghermaz Azarshahar' had maximum plant height; minimum plant height was in 'Primavera' and 'P80'; maximum dry weight of bulbs was in 'Ramhormozy' and it was often followed by 'G1' and 'Sarkareh'; 'Ghermaz Azarshahar' had maximum fresh and dry weights of leaves but maximum fresh bulb weight, at this stage, was by 'Ramhormozy' followed by 'Sarkareh'. Maximum bulb diameter was found in 'Sarkareh' and the maximum number of closed scales was demonstrated by 'Sarkareh', which statistically was not different to 'P80'. Lateral buds of 'Sarkareh' produced many closed scales (**Table 2**) but the shoot apex continued to produce leaves. This cultivar was not prepared for harvesting, because it did not enter the dormancy period and continued its growth and development.

Harvesting

The maximum and minimum fresh bulb weight in m^2 was in 'G1' and 'Primavera', respectively. Maximum bulb number larger than 5 cm than was in 'G1' but statistically there was no significant difference between 'G1', 'P80', 'Ramhormozy', and 'B1'. With respect to the number and weight of 3-5 cm bulbs, the maximum number was produced by 'Primavera', 'Texas Yellow Grano', and 'Ghermaz Azarshahar' and the minimum by 'G1' (**Table 3**). Considering the preparation of bulbs, harvesting was done in 3 stages.

The first harvest of bulbs of earlier cultivars occurred from the 21st April to the 5th May. Earlier cultivars in this experiment included: 'Primavera', 'Texas Yellow Grano', 'Texas Early Grano', and 'P80'. 'Primavera' was earlier than others. This cultivar began rapid growth in the nursery before transplanting, but after transplanting – because it did not have enough time for compensation of stress due to transplanting – it suffered a severe reduction in yield, although it had a high "capacity" for high yield; other earlier cultivars suffered many losses also due to an incapacity to tolerate this stress. Among earlier cultivars only B80 could tolerate this stress better than other cultivars and could produce a good yield.

The second harvest was related to native cultivars which included: 'B1', 'Ramhormozy', and 'G1'. These bulbs were prepared from 20th May to 5th June. Stress at transplanting affected these cultivars as in the first group, but because they had enough time for compensation and a later reaction to environmental factors, they could produce a better yield.

The third harvesting referred to non-native cultivars which included: 'Daaman', 'Sarkareh', 'Shahdad', 'Bardseer', and 'Ghermaz Azarshahar'. These bulbs were prepared to harvest from 20th May to 5th June. These cultivars entered dormancy very late and bulb production also began very late. Here it is worth mentioning that if temperature did not reach 40°C or more as found in native Khuzestan conditions, it was highly probable that they would continue to grow until many of them produced inflorescences.

Temperature change and humidity from November to July in the field showed that in this period, the average, maximum, and minimum temperature, respectively were 20.5, 47, and 4°C. This average temperature allowed for preparing good conditions for growth and development of bulbs (the optimal temperature for growth and development was claimed to be 20-25°C (Brewster 1994)). But temperatures of above 35°C and lower than 10°C caused changes in growth and development of plant. Temperatures lower than 12°C induced vernalization of the plant. This phenomenon induced the production of seedlings in some non-native cultivars ('Bardseer', 'Shahdad', 'Ghermaz Azarshahar', 'Daaman'). But high temperatures (above 35°C) stopped growth and development of onion, especially the production of leaves and scape.

Table 4 Changing dynamics rate of bulbing from 126 days after emergence to first harvesting time.

Cultivar	Rate of bulbing			
	after 126 days	after 150 days	after 164 days	after 186 days
Texas Early Grano	1.77 a	2.58 abc	2.15 ef	5.05 bcd
Primavera	1.66 ab	3.17 a	5.16 a	7.32 ab
P80	1.61 abc	2.71 ab	3.68 bc	8.01 a
Texas Yellow Grano	1.45 bc	2.63 ab	4.59 b	5.95 abc
Daaman	1.57 abc	1.61 d	1.79 ef	2.40 e
B1	1.51 abc	2.10 bcd	2.40 def	5.68 abc
Sarkareh	1.51 bc	1.60 d	2.74 cde	3.37 cde
Ghermaz Azarshahar	1.47 bc	1.38 d	1.31 ef	1.44 e
Ramhormozy	1.47 bc	1.75 cd	3.30 dc	5.72 abc
G1	1.44 bc	1.60 d	1.64 f	3.15 cde
Bardseer	1.37 c	1.38 cd	1.54 f	2.68 de
Shahdad	1.35 c	1.62 d	1.55 f	2.24 e

* Different letters within a column indicates a significant difference by Duncan's Multiple Range Test, $P = 0.05$.

Fig. 1 Variation in 'Shahdad' at harvesting time.

It is clear that short day cultivars rapidly react to changes in photoperiod (11-13 h) and temperature (20-30°C) more than moderate and long day cultivars and produce bulbs. This means that the shorter the time in these conditions, the faster the bulbs formed. The bulbing rate is the ratio of the largest bulb diameter to its neck diameter, and when this ratio reaches 2, bulb formation begins (Mondal *et al*. 1986). According to **Table 4**, the reaction of cultivars to environmental changes is not equal. These changes can be seen by the bulbing rate. When onions of south Iran were studied, it was clear that each native cultivar could develop into a collection of various phenotypes in different weather conditions, where each phenotype could be suitable for the production of a cultivar in a particular region. These phenotypes, after various selections, can produce cultivars. In Africa, 'Radium' and in the USA 'NuMex Camino' were produced in this way (Klashorst *et al*. 1992; Cramer and Corgan 2003). Based on the classification in **Fig. 1**, the studied cultivars can be divided into three big groups. The first group is made up of 'Primavera', 'Texas Yellow Grano', 'Texas Early Grano', and 'Ghermaz Azarshahar'.

'Shahdad' have global expansion as does 'Ghermaz Azarshahar', sown where onion cultivation involves sowing in spring. However, if the appropriate phenotypes are selected 'Shahdad' (**Fig. 1**) can be sown in other places. Their low yield is the main reason for placing them in one group. Regarding stress at transplanting, members of this group react quickly to photoperiod and severe hot temperature at the end of the production season, with low yield in three foreign cultivars ('Primavera', 'Texas Yellow Grano', and 'Texas Early Grano') (Hu *et al*. 2003). But most plants of two Iranian cultivars ('Ghermaz Azarshahar' and 'Shahdad') produced few real bulbs and did not have a suitable reaction to the region's photoperiod and few assimilates were transported to scales.

The second group (**Fig. 2**) includes: 'Sarkareh', 'P80', 'Bardseer', 'B1', 'Daaman', and 'Ramhormozy'. Their high yield was the selection criterion for them to be allocated to this group. Their reaction to the region condition was probably the first group. Perhaps after selection, suitable cultivars of this region will be required in the future. Only 'G1' was significantly different to other cultivars, displaying the highest yield among all cultivars.

Local onions have been sown for good characters in many regions (Rivera-Martinez 2005). Finding and selecting good characters is possible if they have various genetic sources. Iranian local onion populations reproduced by open pollination display variation (Azimi *et al*. 2000; Dehdari *et al*. 2001).

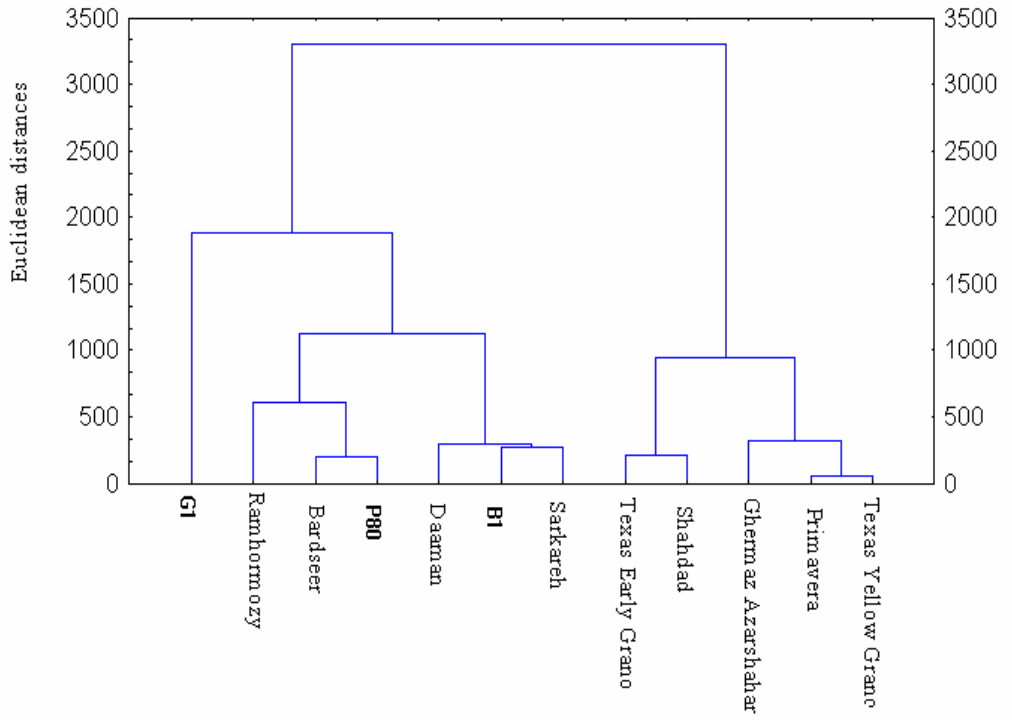

Fig. 2 Distances between cultivars on basis Euclidean distances (complete linkage).

Many researchers tried to find methods to make onion seeds germinate earlier and then produce normal seedlings (Caseiro *et al*. 2004; Tajbakhsh *et al*. 2004); for example the seeds of 'Ghermaz Azarshahar' germinate early and can produce good seedlings. This cultivar is an intermediate day cultivar (Ansari 1997).

One of main problems of onion cultivation is early flowering in subtropical regions. Early flowering in onions depend on cultivar, sowing date, and cultural management (Hu *et al*. 2003; Abe and Nakazumi 2004). It is possible to select plants between Iranian local onion populations and non-bolting types, and those that can produce plants with good bulbs, resulting in a suitable shelf-life in hot conditions.

In various cultivars, bulb formation rate depends on photoperiod and temperature. The reaction of various cultivars to an environmental within the same region is different (Brewster 1997). As witnessed in this study, large variations over time could be seen between bulb formation within and between various cultivars, especially 'Sarkareh', 'Bardseer', 'Shahdad', and 'Daaman'. These variations result from the plants' reaction to photoperiod and temperature in the experimental region. Because each plant reacted differently, there must have been genetic variations between them. Positively, these variations can be used for selection in the future.

CONCLUSIONS

The best characteristics of the studied cultivars were:

1) 'Ghermaz Azarshahar' has fast and uniform germination.

2) 'Sarkareh' has better tolerance against transplanting stress. Foreign cultivars sow late, and have lower tolerance against transplanting stress provided that they are cultivated directly, especially in the last phases of cultivation.

3) 'P80', with regards to early maturation and yield, can be prepared for suitable selection for foreign cultivars especially when the planting season is late.

4) With respect to differences with non-native cultivars, it is possible, with continuous selection, to successfully produce suitable cultivars for this region in Iraq in the future.

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