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Effect of irrigation methods and transplant size on onion cultivars yield and quality

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Abstract

Onions are generally established either by direct seeding or bare root transplants. Compared to direct seeding, transplanted onions provide for an immediate and complete stand. The effect of transplant age on yield is an issue often broached by growers of horticultural and agronomic crops in an effort to maximize production potential. The experiment was arranged in a randomized complete block (split plot factorial) with irrigation method as main plot and three varieties and two planting methods on ridges and flat as subplot and replicated three times. Results showed that irrigation method only affected on bulb weight and leaf sheath length. In other hand transplant size had significant effect on neck thickness, total plant weight, bulb weight, bulb diameter, leaf sheath length, yield and root weight. Between tested cultivars Qooli Qesse resulted the highest yield.

Key words: Onion, planting method, irrigation system, transplanting, transplant size.

Introduction

The onion (*Allium cepa* L.) belongs to the plant family of Alliaceae and is one of the earliest vegetable crops. Its origin was traced to different parts of Asia, namely Central Asiatic region, including North Pakistan, Afghanistan, and eastern USSR [14]; West Asia, extending to Palestine and India [1] and Middle and South-eastern Asia [4].

Onion is grown in more than 135 countries in the world producing 29.3 billion kg of onion bulbs each year. About 8-9 percent of this enters the world trade. The leading onion producing countries are China producing 12.03 million metric tons (average yield is 20.9 t/ha) on 575,820 ha, India producing 5.47 million metric tons (average yield is 11.37 t/ha) on 480,600 ha and United States producing 2.44 million metric tons (average yield is 4.28 t/ha) on 68,000 ha [2].

Onion is a bulbous crop widely cultivated in almost every country of the world and it is the main spice crop in Iran. It is widely used in cooking as spices, salad and food dressing and also for medicinal purposes. Onion bulb is rich in phosphorus, calcium and carbohydrates. A medium onion (50 g in weight) contains 60 calories, 1 g proteins, 16 g carbohydrate, no fat, 5 mg sodium, 200 mg potassium and 3 g dietary fiber [8].

Onions are generally established either by direct seeding or bare root transplants. Compared to direct seeding, transplanted onions provide an immediate and complete stand. The effect of transplant age on yield is an issue often broached by growers of horticultural and agronomic crops in an effort to maximize production potential. Previous research has shown that large onion bulbs can be produced with 8-10-week old containerized transplants grown in small cell volume, or with 10-12-week old transplants grown in large cell volumes [6].

Vachhani and Patel [11, 12] in India used red onion transplants from 4 to 10 weeks old and found yields increased with increasing age to 7 weeks. Yields then gradually decreased with older plants. Lujan-Favela [7] in Mexico, compared planting date and transplant age with a white Grano cultivar, showing the highest yields from 7-week-old transplants set in mid-September. Lujan-Favela correlated yield with transplant size, suggesting larger was better. Wojtaszek *et al.* [15] grew 30-, 40- and 50-d-old onion transplants in peat blocks (5 seed per block) for spring onions in Poland. They found no effect of age on marketable yield. Herison *et al.* [3] in Michigan used three cultivars of containerized Spanish type onions, 8, 10 and 12 weeks of age. Although bulbs essentially matured at the same time, the 10- and 12-week-old transplants yielded larger bulbs. This response was positively correlated with larger plants at transplanting. Yield response in onions may be more the result of plant size than age as both Herison *et al.* [3] and Lujan-Favela [7] suggested. Herison *et al.* [3] noted higher N rates during transplant production resulted in larger seedlings (regardless of age) and greater yields. Most onion transplants are field grown due to the population density required per unit area. Wojtaszek *et al.* [15] and Herison *et al.* [3] conducted studies with containerized plants but Vachhani and Patel [12] and Lujan-Favela [7] gave no indication whether their studies involved containerized or bare root transplants.

Since containerized transplants are costly compared with direct seeding, it is necessary that they produce a high value onion bulb size to offset the high initial cost of establishment. Irrigation water management constitutes a critical factor for increased bulb yield.

The objective of this study was to determine the effects of stand establishment (transplants vs. direct seedling) grown with two planting methods on yield and quality of some onion cultivars.

Materials and Methods

The experiment was conducted from 20 May to 20 October 2003 on the field of Zanjan Agricultural Research Center, Iran. The cultivars used, Qooli Qesse, Sefid Qom and Qermez Azarshahr, had a growing season of up to 5 months. The soil was a sandy loam, pH 7.8, containing total N 2.8%, total C 2.7%, Ca, P and K 10, 13 and 404 mg·kg^{-1}, respectively, and EC 0.09 dS·cm^{-1}. The soil was prepared by plowing and disking. Prior to establishment of onion the soil was formed into beds or plots. Beds were 40 cm wide and plant density was 300,000 plants/ha for both planting method.

Granular fertilizer, 100N-80P-200K kg·ha^{-1}, was broadcasted to beds before seeding according to results based on soil tests and worked into the soil. Plots were 2 m long with 40 cm inter-row and 10 cm intra-row distance. Irrigation was done weekly by using two methods, furrow and flooding irrigation. Bulbs were harvested when received the marketable size. Total yield was calculated on a hectare basis. Plant height, bulb diameter, leaf number, bulb neck thickness, biomass, bulb weight, 5th leaf length and leaf husk length were measured.

During bed preparation soil pH to a depth of 20 cm was measured in a 1:2.5 (v/v) soil-H_2O suspension with a 716 DMS Titrino pH meter (Metrohm Ltd., Herisau, Switzerland) fitted with a glass electrode [11]. Total soil carbon was determined by oxidation with potassium dichromate and titration of excess dichromate with ammonium ferrosulfate [5]. Soil electrolytic conductivity (EC) was determined in a saturated solution extract of the soil [9]. The mineral N concentrations (NH_4-N and NO_3-N) in soil were determined in a Kjeldahl digestion.

The experiment was arranged in a randomized complete block (split plot factorial) with irrigation method as main plot and three varieties and two planting methods as subplot and replicated three times. The data were subjected to general linear models (GLM) procedure in SAS (ver. 9.1, SAS Institute, Inc.) and appropriate means were separated using the Tukey test. To determine the relationship between two different characters, the correlation coefficient (R) was calculated using the Proc Corr statement in SAS.

Results and Discussion

Irrigation method: Irrigation method only affected on bulb weight and leaf husk length (Table 1). Between two irrigation systems flooding had heavier bulb and shorter leaf husk length than furrow irrigation (Table 2). Due to high correlation between bulb weight and total yield (Table 3) agriculturists are able to achieve more yields by flooding system. However, this method needs more water source and this must be checked previously. Some recent research and tools [10] have focused on increasing the application efficiency and uniformity of furrow irrigation.

Transplant size: In agreement with previous reports [3, 7, 12, 13] transplant size had significant effect on neck thickness, total plant weight, bulb weight, bulb diameter, leaf husk length, yield and root weight (Table 1). By increasing transplant size, total plant weight, bulb weight, and total yield increased (Table 4), and we recommend agriculturist to use transplants with 20-25 cm height to increase their yield.

Table 1. GLM table of effects of treatments on onion characteristics.

S. O. V	d. f	Mean square				
		Leaf number	Plant height (cm)	Neck diameter (cm)	Total plant weight (g)	Bulb weight (g)
Rep.(R)	2	11.74ns	69.92ns	1.03**	6529.28*	1000.05ns
Irrigation method (A)	1	17.08ns	32.11ns	0.01ns	3130.40ns	3418.35*
R*A	2	2.91	11.23	0.29ns	1274.64ns	1365.80ns
Transplant size (B)	1	23.36ns	32.87ns	0.78**	8399.72*	13463.73**
A*B	1	2.89ns	0.01ns	0.002ns	2740.52ns	1843.27ns
Cultivar (C)	2	115.32ns	1461.04**	3.36**	1676.80ns	20124.59**
A*C	2	16.40ns	10.65ns	0.15ns	2121.11ns	196.97ns
B*C	2	3.97ns	50.10ns	0.06ns	322.40ns	1435.03ns
A*B*C	2	0.79ns	5.96ns	0.11ns	2757.43ns	1294.83ns
Error	20	6.58	23.24	0.09	1526.88	503.25

Table 1. Continue.

S. O. V	d. f	Mean square				
		Bulb diameter (cm)	Root weight (g)	Leaf length (cm)	Leaf sheath length (cm)	Yield (t. ha^{-1})
Rep.	2	0.29ns	0.81ns	108.32ns	12.31*	9.00ns
A	1	1.52ns	3.12ns	0.59ns	13.94*	3.08ns
R*A	2	0.58ns	1.46ns	22.48ns	0.57ns	1.23ns
B	1	7.47**	14.19**	2.56ns	27.39**	1.21**
A*B	1	0.28ns	0.69ns	41.82ns	6.93ns	1.66ns
C	2	13.44ns	63.10**	701.59**	32.05**	1.81**
A*C	2	0.13ns	0.49ns	27.99ns	0.66ns	1.77ns
B*C	2	0.90*	2.25ns	118.38ns	10.66ns	1.29ns
A*B*C	2	0.32ns	0.14ns	30.77ns	0.83ns	1.17ns
Error	20	0.25	0.77	44.21	3.29	4.53

NS, *, ** non-significant or significant at P≤ 0.05 or P≤ 0.01, respectively, GLM.

Table 2. Effect of irrigation method on onion bulb weight and leaf husk length.

Irrigation method	Bulb weight (g)	Leaf husk length (cm)
furrow	124.09	14.27
flooding	143.58	13.02

Table 3. Correlation between measured characteristics.

	Leaf number	Plant height	Neck diameter	Total plant weight	Bulb weight	Bulb diameter	Root weight	Leaf length	Leaf husk length	Yield
Leaf number	1	0.71**	0.70**	0.36*	-0.49**	-0.54**	0.75**	0.50**	0.23ns	-0.49**
Plant height		1	0.78**	0.37*	-0.52**	-0.68**	0.66**	0.75**	0.44**	-0.60**
Neck diameter			1	0.37*	-0.52**	-0.61**	0.73**	0.46**	0.34*	-0.52**
Total plant weight				1	0.40*	0.26ns	0.22ns	0.34*	0.48**	0.40*
Bulb weight					1	0.96**	-0.59**	-0.50**	-0.01ns	0.99**
Bulb diameter						1	-0.71**	-0.57**	0.01ns	0.96**
Root weight							1	0.50**	-0.04ns	-0.59**
Leaf length								1	0.37*	-0.50**
Leaf sheath length									1	-0.01ns
Yield										1

NS, *, ** non-significant or significant at P≤ 0.05 or P≤ 0.01, respectively.

Table 4. Effect of transplant size on onion characteristics.

Transplant size	Neck diameter (cm)	Total plant weight (g)	Bulb weight (g)	Root weight (g)	Leaf sheath length (cm)	Total yield (t/ha)
10-15 cm	3.00	206.52	114.50	3.90	12.77	34.35
20-25 cm	2.71	237.07	153.18	2.64	14.52	45.95

Table 5. Effect of cultivar on onion characteristics.

cultivar	Plant height (cm)	Neck diameter (cm)	Bulb weight (g)	Root weight (g)	Leaf length (cm)	Leaf sheath length (cm)	Total yield (t/ha)
Qooli Qesse	48.98bz	2.32c	178.03a	1.55b	31.69b	11.94b	53.41a
Sefid Qom	70.20a	3.38a	97.17b	5.87a	46.77a	13.79ab	29.15b
Qermez Azarshahr	64.85a	2.85b	126.31b	2.39b	41.42a	15.20a	37.89b

[z] values in a column followed by the same letter are not significantly different at P≤ 0.01, Tukey test.

Cultivar: Between tested cultivars Qooli Qesse produced the highest yield, but due to big neck (Table 5) the pest control has to be done carefully. Although bulbs essentially matured at the same time, the transplants with 20-25 cm length yielded wider bulbs (Table 5). This response was positively correlated with larger plants at transplanting. Yield response in onions may be more the result of plant size than age as both Herison *et al*. [3] and Lujan-Favela [7] suggested.

Table 6. Effect of transplant size and cultivar interaction on onion bulb diameter.

Transplant size	Cultivar	Bulb diameter (cm)
10-15 cm	Qooli Qesse	7.22az
10-15 cm	Sefid Qom	5.30b
10-15 cm	Qermez Azarshahr	5.83b
20-25 cm	Qooli Qesse	8.03a
20-25 cm	Sefid Qom	5.72b
20-25 cm	Qermez Azarshahr	7.33a

[z] values in a column followed by the same letter are not significantly different at P≤ 0.05, Tukey test.

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