AcademicPres

Available online at www.notulaebiologicae.ro

Print ISSN 2067-3205; Electronic 2067-3264

Not Sci Biol 2 (1) 2010, 88-93

Notulae Scientia Biologicae

Evaluation Effects of Different Planting Systems on Water Use Efficiency, Relative Water Content and some Plant Growth Parameters in Onion (*Allium cepa* L.)

Mousa IZADKHAH[1)], Mehdi TAJBAKHSH[2)], Mohamad Reza ZARDOSHTY[2)], Abdollah HASANZADEH GORATTEPH [3)]

[1)] *Urmia University, Faculty of Agriculture Science, 47402-1027 Bloomington, Iran; ms.izadkhah@gmail.com*

[2)] *Urmia University, College of Agriculture, West Azerbaijan, Iran; mahditajbakhsh@yahoo.com*

[3)] *Agricultural and Natural Resources Research Institute, West Azerbaijan, Urmia, Iran; ahassanzadeh_g@yahoo.com*

Abstract

To evaluate the effect of different sowing methods on water use efficiency, relative water content and some vegetative growth parameters of onion a study was carried out in the Agriculturalr research Center of East Azarbayjan in 2007-2008 cropping season. The experiment was a factorial by using the randomized complete block design with 4 treaments and 4 replications. The first factor was consistting of two sowing methods, dirct sowing (DS) and the transplanting method (TM), the second factor was including two onion cultivars 'Azarshahr' (red hull and later maturing) and 'Gooli-Ghesseh Zanjan' (bright-red, early maturing). Analysis of variance for the measured traits indicated that except for the relative water content (RWC), other traits were significant influenced by the sowing methods. TM had higher values of water use efficiency (WUE), bulbing ratio (BR), aerial leaves length (ALL), leaf area (LA), leaf area index (LAI), leaves dry weight (LDW), leaves fresh weight (LFW) and leaves saturation weight (LSW) than the DS methods. Maximum WUE (6.07 kg m^3) and minimum WU (9381 $m^3 ha^{-1}$) were obtained in TM. However, the lowest WUE (4.19 kg m^3) and the highest WU (115921 $m^3 ha^{-1}$) was obtained with DS. In other words, in TM water economizing was 1.5 tim, amount of yield was increased up 15% (in comparison with DS). Also among the cultivars except for the RWC, WUE and BR other traits were significantly. The sowing method x cultivar interaction were not significant. For the studied traits, TM and red 'Azarshahr' cv. were better than the DS and 'Gooli-Ghesseh Zanjan', thus thy were identified the best treatments for experiment therefore it is recommended for the places with the same environmental conditions of this experiment.

Keywords: onion, water use efficiency, relative water content, transplanting method (TM), direct sowing (DS)

Introduction

Onion (*Allium cepa* L.) is a bulbous crop widely cultivated in almost every country of the world. It is one of the important condiments being widely used either in green form or as mature bulb or both used as salad and in preparations of immeasurable number of dishes, like soups, sauces and for seasoning of foods. The smaller bulbs are pickled in vinegar. Onion bulb is rich in phosphorous, calcium, and carbohydrates, along with this a medium onion (50 g in weight) contains 60 calories, 1 gram proteins, 16 grams carbohydrate, no fat, 5 milligrams sodium, 200 milligrams potassium, dietary fiber 3 grams. In Iran, there has been a progressive increase in its cultivated area and production. In 2007-2008 a total area of 500 thousand hectares, with total production of 1600 thousand tones of onion bulbs were reported, resulting an average yield of 34.04 tones ha^{-1}. Onions can be direct seeded in the field, trans-planted and grown from onion sets. TM has a beneficial effect on onion production in several reasons for using transplants: transplanted crops normally mature earlier than field drilled crops of the same cultivar, higher total, marketable and biological yield, harvest index and homogeneous bulbs than DS and also prevents a change in soil structure. The commercial production of large bulbs from transplants is the most prevalent in regions where the onion crop is grown during the winter and harvested in the spring. However, it is also practiced in regions where onions are grown as a summer crop-not only to give a longer growing season for late-maturing cultivars, but also to give early-maturing types an opportunity to make sufficient growth before long days and high temperatures force them to bulb. Finally, the yields from transplanted crops are usually higher than from directly sown crops. The transplanting method (TM) in more common than direct sowing (DS) in onion production and research in developed countries (Kvet *et al.,* 1971; Hegde, 1978; Nagre *et al.,* 1984; Iortsuun and Khan,

Received 07 November 2010; accepted 20 February 2010

1989; Farrage, 1989; Atter *et al.,* 1991; Matsui *et al.,* 1994). In trials with the onion cvs. Yellow Berrnuda and Granex the highest yields resulted from TM and the lowest from DS (Ramtohul and Splittstoesser, 1979).

Khokhar *et al.* (1990) obtained data on bulb maturity, bulb weight and yield either directly in the field or in the nursery followed by transplanting at 3 dates, for each method. The differences between methods and dates were highly significant TM gave batter results for bulb yield (5.2-31.4 t/ha) and bulb weight (80.5-441.4 g) than DS (6.4-26.8 t/ha and 20.8-177.8 g, respectively. Izadkhah *et al.,* (2009) reported that TM produces a higher plant single yield, biological yield and harvest index than DS in Iran. Rao (1988) indicated that TM gave the highest leaf area (LA), dry matter (DM), leaf area index (LAI), crop growth rate(CGR) and net assimilation rate(NAR) than DS in the field.

In onion production areas of Iran, the farmers are not aware of the advantages of TM .They sow onion seeds as DS and then cover them with sand in order to facilitate germination, emergence of seeds and seedling establishment. This method is one of the most important causes of changes soil texture in onion production areas. In addition the bulbs have larger variation in diameter and weight. The present study was aimed at comparing the two sowing methods of DS and TM for Plant water relation and the vegetative growth parameters.

Materials and methods

Field experiment was carried out in the Agricultural research Center of East Azarbayjan in 2007-2008 cropping season. The experiment was laid out using Randomized Complete Block Design (RCBD) with factorial arrangements. The experiment consisted of 4 treatments and four replicates. The first factors were two sowing methods, Dirct sowing (DS) and the transplanting method(TM), while the second factor were two onion varieties 'Azarshahr' and 'Gooli-Ghesseh Zanjan' Tab. 1.

The total area of each plot was 8 m^2 being divided into 10 rows with 4 m length and 2 m width. The spacing was 20 cm between rows and 10 cm between plants. For nursery raising, onion seeds were sown on 9th February, 2007 in raised bed. On 25th March 2008, the sets of the two cultivars were sown at a rate of 25 kg/ha (with a final density of 5×5 cm or 400 plants/m^2) in Ds and the seeds were then covered with sand at 62 kg/plot in all DS plots, the seedling of the two cultivars were also transplanted at 20×10 cm or 50 plants/m^2 on 30th Aprill 2008 for TM. The seedlings were transplanted in their respective plots at two leaves stage and had the characteristics shown in Tab. 2.

The physical and chemical characteristics of experiment soil such as pH, ECe, organic matter, NPK were calculated (17) and presented in Tab. 3. Fertilizers was applied at the rate of (150:50:100) $N:P_2O_5:K_2O$ kg ha^{-1}. Di Ammonium phosphate and Sulphate of Potash, were applied to all treatments at the time of field preparation. Nitrogen fertilizer, in the form of urea, was applied as two equal doses, 45 and 90 days after seedlings transplanting of each plots. All other common farming practices for the onion were also performed.

Irrigation was scheduled based on cumulative pan evaporation (CPE) when reached to 37 mm, registered from a computerized weather station.

A surface irrigation system was used to irrigate plants. Amount water consumption was recorded by volumetric counter in different treatments, during 7 day intervals. During the growing period and after harvesting, some plant growth measurements were taken to determine difference in plant water relation and vegetative growth as affected by different planting methods. In August and October 2008, 'Gooli-Ghesseh Zanjan' and 'Azarshahr' respectively the bulbs of each plot were harvested when they were fully matured.

Plant water relation measurements, including: relative water content (RWC), water use efficiency (WUE) and water used (WU) was conducted. Water use efficiency values were calculated with by dividing of the total bulb yield kg by m^3 water consumed according to the following equation (Begg and Turner, 1976).

$$WUE = \frac{\text{Total bulb yield (kg/ha)}}{\text{Seasonal ET } (m^3/ha)} = \text{kg/ha-m}^3 \text{ water}$$

Tab. 1. Characteristics of onion cultivars used

Cultivars quality	Origin	Bulb Shapes	Skin color	Flesh color	Growing period (Day)	Storage
'Azarshahr'	Iran	Globe	Red	White Purple	188-190	High
'Gooli Ghesseh-Zanhan'	Iran	Flattened globe	Brown Red	White	155-159	Medium

Tab. 2. Seedling characteristics (after 75 days)

Characteristics	Length of Seedling (cm)	Bulb diameter (mm)	Diameter neck (mm)	Length of roots (mm)	Number of roots	Number of leaves
Mean	20	4.57	3.21	51.26	9.70	2-3
Standard error	1.7	0.284	0.15	3.18	1.18	-

Tab. 3. Physical and chemical characteristics of crop experimental soil

Soil Characteristics	Unit	Value Texture
Sand	%	42
Silt	%	37
Clay	%	21
Textural Class	Sandy loam pH	7.9
Ece	dSm^{-1}	0.53
Nitrogen	$g100g^{-1}$	0.43
Available Phosphorus	$mg\ kg^{-1}$	4.50
Potassium	$mg\ kg^{-1}$	218
Organic Matter	$g100g^{-1}$	0.53

Relative water content: to determine RWC, after a period of two weeks without irrigation before harvest treatments, five plants were randomly taken from each plot, immediately leaves fresh weight was weighed, then the leaf samples were chopped to small pieces and placed into a container with distilled water at darkness for a period of 4 hr to a measurement saturation weight leaves (SWL), then leaf samples were dried by paper towel and placed into a oven dried at 80°C for a period of 48 hr and dry weight (DW) weighting by sensitive digital balance (with accuracy of 0.0001 G). The RWC measurement was carried out according to (Barr *et al.,* 1962):

$$RWC = \frac{F_W - D_W}{S_W - D_W} \times 100$$

Where: RWC = relative water content, FW = fresh weight leaves, DW = dry weight leaves, SW = saturation weight leaves.

The measurements vegetative growth parameters were included: length of the aerial leaves (ALL), saturation/dry/fresh weight leaves (LSW, LDW, LFW), leaf area (cm^2), leaf area index, harvesting date (HD), bulbing ratio(BR) and number of days bulbing.

The leaf area index (LAI) was calculated according to Winter and Ohlrorgge (1988) as follows:

$$LAI = \frac{\text{Leaf area / plant}}{\text{Land area / plant}}$$

Bulbing ratio was calculated by dividing bulb diameter by neck diameter. Leaf area was determined by the nondestructive method of Gamiely *et al.* (1991) using the following equation area =-93.1+1.83L+38.6 C25, where 'L' is total leaf length (in centimeters) and C25 is leaf circumference(in centimeters) at 25% total leaf length from the leaf base. This equation gave high predictability with coefficient of determination of 0.96.

The data for the water use efficiency (WUE), relative water content (RWC), water used (WU), harvesting date (HD), bulbing ratio (BR), number of day bulbing, aerial leaves length (ALL), leaf area (LA), leaf area index (LAI), leaves dry weight (LDW), leaves fresh weight (LFW) and leaves saturation weight (LSW) were transformed according to procedures described by Steel and Torrie (1991) to improve normality. The data collected were subjected to statistical analysis of variance using the Statistic Analysis System (SAS) version 8.2. Treatment means that were significantly different were compared using Duncan's Multiple Range Test (DMRT) according to Gomez and Gomez (1984).

Results and discussion

Plant water relation parameters

The plant water relation traits such as water use efficiency (WUE), relative water content (RWC) and water used (WU) have been presented in Tab. 4. Results showed that, except for the relative water content, other traits such as water use efficiency, and water used were significantly influenced by the sowing methods. The interaction effect of sowing method and varieties showed a non significant on the plant water relation (Tab. 4). TM gave the highest water use efficiency (WUE) and lowest water used (WU) (6.07kg/m^3, 9532 m^3/ha^{-1} respectively) whereas the lowest values water use efficiency (WUE) and highest water used (WU) were obtained from DS (4.19 kg/m^3, 11441 m^3/ha^{-1} respectively) (Tab. 5). In other words, in TM water economizing was 1.5 tim, amount of yield was increased up 15% (in comparison with DS). These results were similar to those obtained by Leskovar *et al.,* (2002). They found that transplants had higher water use efficiency than direct seeded plants (average of 6,307 vs. 4,400 lb/inch water applied+rain). Also the varieties showed except for the water used, other traits were non significant difference on the plant water relation traits. The hightest water used. were found in red 'Azarshahr' (11592 m^3/ha^{-1}) while the lowest were obtaind in 'Gooli-Ghesseh Zanjan'(9381 m^3/ha^{-1}) (Tab. 5).

Vegetative growth parameters

Harvesting date

The Analysis of variance for harvesting date indicated a highly significant difference on it and influenced by the sowing methods and cultivars Tab. 4. The varieties and their interaction with sowing methods showed a non significant difference on harvesting date.

The mean harvesting date was 167 days after transplanting in TM. However, the harvesting date for the DS was longer than the TM (187 vs 167). There was decreased in harvesting date for TM (Tab. 5). These findings were harmony with those reported by Ramtohul and Splittstoesser (1979), Sabota and Downes(1975). Also, the highest harvesting date (188 day) were obtained from red

Tab. 4. Analysis of variance effect of sowing methods and cultivars on water use efficiency, relative water content, water used, harvesting date, bulbing ratio and number of day bulbing

Trait / Source of variation	df	WUE (kg/m^3)	RWC (%)	WU (m^3)	HD(Day)	BR	No. of Bulbing (Day)
Block	3	0.2772ns	23.321ns	0.002ns	55.229ns	0.6796ns	15.500ns
Sowing methods (SM)	1	14.118**	3.250ns	1457.2**	1660.56**	8.558*	164.25**
Cultivars (C)	1	0.189ns	45.320ns	1954.84**	218.562**	0.567ns	3969**
SM × C	1	0.0232ns	0.232ns	40.65ns	0.0012ns	30.25ns	5.062ns
Error	9	0.0150	0.236	23.123	26.395	0.8182	9.222
cv		2.38	12.35	1.25	2.89	8.18	4.11

WUE: Water Use Efficiency; RWC: Relative Water Content; WU: Water Used; HD: Harvesting Date; BR: Bulbing Ratio and No. of Bulbing: Number of day Bulbing
*, ** & ns: Significant at p<0.05, p<0.001, non-significant respectively

'Azarshahr', whereas lowest were found in 'Gooli-Ghesseh Zanjan'(165 day) could be due to varieties, Tab. 5.

Bulbing ratio and number of day bulbing

The bulbing ratio (BR) and number of day bulbing were significantly influenced by the sowing methods, but the bettwen two cultivars bulbing ratio did not differ in these respects (Tab. 4). Significant interaction sowing method ×cultivar were not observed on the general responses of the studied this characters (Tab. 4). The maximum bulbing ratio and the minimum number of day bulbing were found in TM (10.99 and 64 day respectively) whereas the minimum bulbing ratio and maximum number of day bulbing were obtaind in DS (9.52 and 83 day respectively (Tab. 5). This agree with the reports of other researchers (Wien, 1999; Ramtohul and Splittstoesser, 1979). The highest mean number of day bulbing (89 day) was found on red 'Azarshahr' and lowest (58 day) was found on 'Gooli-Ghesseh Zanjan' which could be due to varieties and day length, field situation etc. (Tab. 5).

In a vertical column values having same letter(s) do not different significantly (p≤0.05) from each other, according to Duncan`s Multiple Range Test (DRMT).

Tab. 5. Mean comparison effect of sowing methods and cultivars on water use efficiency, relative water content, water used, harvesting date, bulbing ratio and number of day bulbing

Trait / Factors	WUE (kg/m^3)	RWC (%)	WU (m^3)	HD (Day)	BR	No. of Bulbing (Day) Sowing methods
DS	4.19b	91a	11441a	188a	9.52b	84a
TM	6.07a	90a	9532b	167b	10.99a	64b
'Azarshahr'	5.03a	89a	11592a	189a	1045a	89a
'Gooli Ghesseh-Zanjan'	5.07a	87a	9381b	165b	10.07a	58b

WUE: Water Use Efficiency; RWC: Relative Water Content; WU: Water Used; HD: Harvesting Date; BR: Bulbing Ratio and No.of Bulbing: Number of day Bulbing.

Aerial leaves length, leaf area, leaf area index

The aerial leaves length (ALL), leaf area (LA), leaf area index (LAI) was measured at the maturity stage and average was computed. The analysis of variance showed there

Tab. 6. Analysis of variance effect of sowing methods and cultivars on length of the aerial leaves, leaf area, leaf area index, saturation/dry/fresh weight leaves

Trait / Source of variation	df	ALL cm^2/plant	LA cm^2/plant	LAI	LDW (gr)	LFW (gr)	LSW (gr)
Block	3	1.343ns	21.932ns	12.56ns	1.254ns	153.335ns	142.1ns
Sowing methods(SM)	1	123.552**	476.255**	359.123**	408.342**	256.221**	149.12**
Cultivars(C)	1	103.022**	678.42**	537.218**	128.084**	9775.33**	548.33**
SM × C	1	0.0202ns	0.687ns	12.032ns	59.02ns	32.26ns	0.258ns
Error	9	1.350	17.214	45.258	2.051	144.009	256.354
cv		3.03	16.38	7.56	8.09	8.56	12.25

ALL, LA, LAI, LDW, LFW & LSW indicates: Aerial Leaves Length, Leaf Area , Leaf Area Index, Leaves Dry Weight, Leaves Fresh Weight, Leaves Saturation Weight.
n.s,* and ** : non- significant; and significant at p<0.05 or p<0.001 level of probability using DMRT, respectively.

Tab. 7. Mean comparison effects of sowing methods and cultivars on length of the aerial leaves, leaf area, leaf area index, saturation/dry/fresh weight leaves.

Trait Factors	ALL cm^2/plant	LA cm^2/plant	LAI	LDW (gr)	LFW (gr)	LSW (gr) Sowing methods
DS	37.47b	1117b	5b	3.58b	35.94b	39.53b
TM	41.23a	1773a	8a	5.33a	57.39a	63.13a
'Ayarshahr'	40.89a	1472.66a	7a	6.94a	63.27a	69.60a
'Gooli Ghesseh-Zanjan'	35.81b	1377b	6b	5.79b	52.94b	58.23b

ALL, LA, LAI, LDW, LFW and LSW indicates: Aerial Leaves Length, Leaf Area , Leaf Area Index, Leaves Dry Weight, Leaves Fresh Weight, Leaves Saturation Weight. Means within the same column followed by the same letter(s) are not significantly different ($p \leq 0.05$ from each other, according to Duncan`s Multiple Range Test (DRMT).

were significant difference between sowing methods and two cultivars on the ALL, LA and LAI (Tab. 6). The highest aerial leaves length, leaf area and leaf area index (41.23 cm, 1773 cm^2/plant, 8 respectively) was observed in TM.

Where as the lowest was obtained in DS (34.47 cm, 1117 cm^2/plant and 5 respectively) Tab. 7. Similar results are observed by other investigators (RAO, 1988; Farrage, 1989; Iortsuun and Khan, 1989). Their interaction with varieties and sowing methods showed a non-significant difference on mentioned traits. There were significant differences between two cultivars on ALL, LA and LAI (Tab. 6). The highest aerial leaves length, leaf area and leaf area index (40.89 cm, 1472.66 cm^2/plant, 7 respectively) was observed in red 'Azarshahr'. Where as the lowest was recorded in 'Gooli-Ghesseh Zanjan' (35.81 cm, 13377 cm^2/plant and 6 respectively, Tab. 7).

Leaves dry weight, leaves fresh weight and leaves saturation weight

Analysis of variance for leaves dry weight (LDW), leaves fresh weight (LFW) and leaves saturation weight (LSW) are shown in (Tab. 5). The sowing methods were difference significantly on the LDW, LFW and LSW traits. The average leaves dry weight, leaves fresh weight and leaves saturation weight increased form 3.58 (g), 35.94 (g) and 39.53 (g) in DS respectively, to 5.33 (g), 57.39 (g) and 63.13 (g) in TM respectively (Tab. 5). Similar results were reported by Iortsuun and Khan,1989. They indicated that TM gave better results for LDW, LFW and LSW than DS (Tab. 5).

There were significant differences between two cultivars for LDW, LFW and LSW traits (Tab. 5). Leaves dry weight, leaves fresh weight and leaves saturation weight, greater in red 'Azarshahr' (6.94 g, 63.27 g and 69.60 g respectively) than in 'Gooli-Ghesseh Zanjan' (5.79 g, 52.94 g and 58.23 g respectively). Sowing method×cultivar interactions were not significant for this treats (Tab. 5).

Based on the above results transplanting method (TM) could be an effective method of producing onions without a change in soil texture. Furthermore due to TM gave the higher water use efficiency (WUE) and lower of amount water used (WU) than DS. In other words, in TM water economizing was 1.5 tim, which can be utilize an other crops, and also amount of yield was increased up 15% (in comparison with DS). Therefore TM is recommended for regions with shortage of water is a limiting factor for agricultural productivity like arid and semi-arid. Thus recommended for the places with the same environmental conditions of this experiment.

References

Atter, S., B. N. Korla and A. Singh (1991). Effect of transplanting dates and varieties on number of leaves and yield in onion *(Allium cepa L.)*. Vegetable Science. 18(1):24-28.

Baloch, A. F., M. A. Baloch, G. Ansari and A. H. Qayyum (1991). Effect of FYM on the yield of onion crop. Sarhad J. Agric. 4(4):34-53.

Barr, H. D. and P. E. Weatherley (1962). A reexamination of the relative turgidity technique for estimating water deficit in leaves. Aust. J. Biol. Sci. 15:413-428.

Begg, J. E. and N. C. Turner (1976). Crop water deficits. Adv. Agron. 28:161-217.

Duncan, D. B. (1955). Multiple range and multiple F test. Biometrics. 11:1-42.

Farrage, M. M. (1989). Effect of inter and intra row spacing on growth , yield and bulb quality of onion cv. Giza 6. Assuit Journal of Agriculture Science. 10(2):187-104.

Gamiely, S., W. M. Randle, W. A. Milks and D. A. Smittle (1991). A rapid and nondestructive methodfor estimating leaf area of onions. HortScience. 26:206.

Gomez, K. A. and A. A. Gomez (1984). Statistical procedures for Agricultural Research John Wiley and Sons. Inc., New York.

Hegde, D. M. (1978). Growth analysis of onion *(Allium cepa L.)* in relation to irrigation and nitrogen fertilization. J. Agron. Crop Sci. 157: 227-234.

Iortsuun, D. N. and A. A. Khan (1989). The pattern of dry mutter distribution during development in onion J. Agron. Crop Sci 162:127-134.

Izadkhah, M., M. Tajbakhsh, M. R. Zardoshti, A. Hasnzade, F. Taheri , M. Saber-Rezaie, F. Feghnabil and S. Parvizi (2009). Invsttigation the influence of planting methods on bulb and

biologic yield, harvest index and some morphological triats in onion (*Allium cepa* L.). Online International J. Agron. and Bio. (OIJAB) 2(4):189-193.

Kvet, J., J. P. Ondok, J. Necas and P. G. Jarvis (1971). Methods of growth analysis. Plant Photosynthetic production. N.V Publisheres.

Leskovar, D. I., K. Kolenda, K. S. Yoo and L. M. Pike (2002). Containerized Onion Transplants: I. A Strategy to Enhance Yield and Size.Texas A and M Agricultural Research and Extension Center at Uvalde.

Matsui, S. M., H. Shirai and Ykamur (1994). Growth analysis of onion *(Allium cepa L.)* plants treated with (s)-(+) abscisic acid. Res. Bull. Faculty of Agric. Gifu Univ. No. 59-27-62.

Nagre, P. K., L. V. Kulwal and P. B. Kale (1985). Effect of different days of transplanting and spacing on growth and yield of onion cv. Local white. PKV Research Journal 11(2):151-155.

Nayerabi, S. A. F. and A. H. M. Ahmed (2001). The Commercial Vegetable of Pakistan Tropical Sci. 41(2):95-99.

Page, A. L., R. H. Miller and D. R. Keeny (1982). Methods of soil analysis. Part©II. Chemical and Microbiological properties 2nd ed. Amer. Soc Agron. Inc. Soil Sci. Sco. Amer. Inc. Madison, Wisconsin, USA.

Ramtohul, M. and W. E. Splittstoessor (1979). Day length determines bulb size and time of maturity in onion. Illinois Research. 21:2-14.

RAO, K. S. (1988). Physiological analysis of growth and yield in onion *(Allium cepa L.)*. Indian J. Agric. Sci. 58(6):489-491.

Sabota, C. and D. Downes (1975). Influence of spacing and transplanting size of maturity in onions *(Allium cepa L.)* grown in West Texas.

Steel, R. G. D. and J. H. Torrie (1991). Principles and Procedures of Statistics a Biometrical Approach. McGraw-Hill Book Company. New York.

Whitesid, W., F. Vandemark and W. E. Splittstoessor (1975). Seedling date and rate and supplement light effects on onion growth. J. Amer. Soc. Hort. Sci. 100:37-39.

Wien, K. C. (1999). The physiology of vegetable crops. CABI Press. New York. p.67.

Winter, S. R. and A. J. Ohlrorgge (1988). Leaf angle, leaf area and corn *(Zea mays L.)* yield. Agron. J. 65:395-402.