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Effect of inter and intra row spacing on the growth and yield components of Onion (*Allium cepa* L.) at Khuja Omeri District, Ghazni, Afghanistan

Ghulam Maruf Faqiri[1], Habibullah Hamayoun[2*], Gul Ahmad Zaherian[3]
[1, 2] Horticulture Department, Agriculture Faculty, Ghazni University, Ghazni, Afghanistan
[3] Professor, Horticulture Department, Agriculture Faculty, Kabul University, Kabul, Afghanistan

Abstract
Onion is one of the most important high market value bulb crops cultivated commercially in most parts of the world. It is the most cultivated and high market value of vegetable crops In Afghanistan specially Ghazni. However, bulb yield of onion is limited due to improper use of plant spacing. Therefore, this study was held to determine the optimum planting spacing of Onion to maximize its productivity in 2016 and 2017 under irrigation conditions. The trial contains treatment of singe planting pattern of 20 x 10, 40 x 10, 30 x 5, 30 x 7.5, 30 x 10 and 30 x 12.5 cm inter and intra spacing respectively and double planting pattern combinations of four intra plant spacing (5, 7.5,10 and 12.5 cm) and two levels of inter spacing (40 and 50 cm) by means of total fourteen treatments were carried out in Factorial Randomized Block Design (FRBD) with three replications. The current findings showed that plant height, bulb size, bulb weight, total bulb yield and marketable bulb yield were significantly influenced by planting spacing. Accordingly, the tallest plant height (37.70 cm) was obtained at a spacing of single planting of 40 cm inter row and 10 cm intra row while the maximum total bulb yield of 27.01 ton ha-1) was recorded at a spacing of double planting pattern of 40 cm inter and 5 cm intra row in both years. Therefore, 40 cm inter row and 5 cm intra rowspacing in double row planting manner is recommended for the growers to improve onion productivity in the study area.

Keywords: onion, inter and intra row spacing, growth and yield

Introduction

Onion (*Allium cepa* L.) belongs to the Alliaceae family Onion is the most important bulb crops cultivated commercially in most parts of the world. The crop is grown for consumption both in the green state. Onions exhibit particular diversity in the eastern Mediterranean countries, through Turkmenistan, Tajikistan, Afghanistan to Pakistan and India, which are the most important sources of genetic diversity and believed to be center of origin (Brewster, 2008) [2]. Onion is one of the most popular and the most cultivated vegetables in Afghanistan in mostly in central part.

It is one of the richest sources of flavonoids in the human diet and flavonoid consumption has been associated with a reduced risk of cancer, heart disease and diabetes. In addition, it is known for anti-bacterial, antiviral, anti-allergenic and anti-inflammatory potential. It pungency is due to volital oil (allylprophyl disulfide). (Muthukumar, P. and Selvakumar R. 2013) [10]

According to Geremew *et al*. (2010) [2], yield and quality of dry bulbs can be influenced by cultural practices andgrowing environments. The higher yieldand better control of over or under bulb size could be obtained if plants are grown at optimum density. Bulb neck diameter, mean bulb weight and plant height decreased as population density increased. Total bulb yield can be increased as population density increases (Kantian*et al*., 2003).

Appropriate spacing enables the farmers to keep appropriate plant population in the field. Therefore, it can avoid excess or less population in a given plot of land which has negative result on yield and quality of onion. Spacing of 40 × 20 × 10 cm between furrow, row and plants, respectively has been used for onion production. But producers complain 10 cm intra row spacing produces large bulb size which is not preferred by consumer for home consumption. (Habtamu*et al*., 2016).

The present study was therefore undertaken to examine the effects of different intra-row and inter row spacing for onion productivity in Ghazni, Afghanistan.

Materials and Methods

Description of the study site: The experiment was held out at KhujaOmeri District of Ghazni Province in 2016 and 2017 under irrigation conditions. The area mean annual rainfall of 750 mm and minimum and maximum annual temperature of 14 and 18°C, respectively. The soil is clay-loam texture f with a pH value of 7.3 at the soil depth of 0-30 cm (Hamayoun*et al*., 2015).

Experimental materials, treatment and design: The trial contains treatment of singe planting pattern of 20 x 10, 40 x 10, 30 x 5, 30 x 7.5, 30 x 10 and 30 x 12.5 cm inter and intra spacing respectively and double planting pattern combinations of four intra plant spacing (5, 7.5, 10 and 12.5 cm) and two levels of inter spacing (40 and 50 cm) by means of total fourteen treatments were carried out in (FRBD). The experiment contains three replications having a plot size of 2.4m x 2 m for each experimental unit. Red variety was used as test crop for the experiment to all treatments. The treatment (T) combination (Table 1) comprised:

Experimental procedure: UREA and DAP were used as the sources of Nitrogen and Phosphorous respectively.46 kg P2O5 ha-1 was applied in band application method at transplanting time. Similarly, 23 kg ha-1of N was applied in two splits 25 days after transplanting and the 35.

Table 1: Treatment combination

Single planting pattern	Double planting pattern
T_1. Flat planting of 20x10 cm	T_7. 40 x5 cm
T_2. 40x10 cm	T_8. 40 x7.5 cm
T_3.30x5 cm	T_9. 40 x10 cm
T_4. 30x7.5 cm	T_{10}. 40 x12.5 cm
T_5.30x10 cm	T_{11}. 50 x5 cm
T_6. 30x12.5 cm	T_{12}. 50 x7.5 cm
	T_{13}. 50 x10 cm
	T14. 50x12.5 cm

Days after the first nitrogen applied. Onion was transplanting when 3-4 true leaves emerged that was in 55 days from the time of sowing. The transplanting time was in the morning in order to decrease the shocking of the plant. Other cultural management practices were done according to the national recommendation for all experimental units.

Data collection and analysis: Data collection: Important morphological growth and yield components of onion was collected.

Morphological and phonological traits: Plant height (cm): Five plants from every net plot area were tagged to collect data of plant height. It was measured using ruler from the soil surface up to the tip the leaves at bulb development stage.

Days to maturity: The actual number of days from transplanting tothe field to a day at which of the plants in a plot showing yellowing of leaves was recorded to determine the days to physiological maturity.

Bulb yield and yield components

Average bulb weight (g): Five plants from the net plot area were tagged to collect data of average bulb weight by gr.

Bulb size (cm): Five plants from every plot area were tagged to collect data of average bulb size and expressed in centimeter. Marketable bulb yield (t ha-1): Total weight of clean, disease and damage free bulbs were measured per net plot and converted to t ha-1.

Unmarketable bulb yield (t ha-1): Total weight of decay, physiological disorder such as thick necked, split and bolters were measured per net plot and converted to t ha-1Total bulb yield (t ha-1): Total weight of marketable and unmarketable bulbs were measured per plot and converted to t ha-1.

The data were collected from middle rows of a net plot area where the two outer most rows of each treatment were left as border effects. In addition, 0.05, 0.075, 0.1 and 0.12 m length in both ends for 5, 7.5,10 and 12 cm intra row spacing, respectively, of each harvestable row were also left as border effects.

Statistical Analysis

All data were subjected to the analysis of variance(ANOVA) and significance difference among the treatment means was computed with Duncan's Multiple Range Test(DMRT) at 5% probability level (Gomez and Gomez, 1984) [3].

Results and Discussion

Growth Parameters

Plant Height

Plant height was significantly affected by planting space in both years. Tallest plant height of 37.70 cm was recorded at single planting spacing of 40 x 10 cm in 2016 where as the shortest plant height of 28.03 cm was recorded at double spacing of 40 x 5 cm. In 2017 irrigation season, the tallest plant height of 53.67 cm) was also recorded at single spacing of 40 x 10 cm while the shortest (40.33 cm) was obtained at double spacing of 40 x 5 cm (Table 2). The greatest plant height may be due to the availability of free access of environmental resources (water, nutrient, lightand wind) for the plants in the wider plants. In line with this result, Tesfalegn (2017) [13] reported that plant height of onion plants was significantly affected by intra spacing of cultivars. The highest plant height was obtained at 10 cm and the lowest plant height at 4 cm. Similarly, Jilani *et al*. (2009) [7] and Sikder *et al*. (2010) [12] also reported the closer intra-row spacing resulted short plant height than wider plant spacing.

Days to 90% physiological maturity

Days to 90% physiological maturity showed no significant (P>0.05) variation to planting spacing (Table 2). This might be due to the less computation of plants for growth resources. Generally, it matured at a range of 82.33 to 88.00 starting from its transplanting time (Table 2).

Table 2: Mean number of days required for physiological maturity and plant heightof onionunder Irrigation

Treatments	Plant height (cm)		Days to maturity		Mean
	2016	2017	2016	2017	
Single planting pattern					
T_1. Flat planting of 20x10 cm	33.18^{a-e}	44.00^{cde}	86.33	83.00	84.7
T_2. 40x10 cm	37.70^{a}	53.67^{a}	85.33	83.67	84.5
T_3.30x5 cm	31.20^{c-f}	48.00^{a-d}	86.00	84.00	85.0
T_4. 30x7.5 cm	35.70^{abc}	49.67^{abc}	86.00	84.00	85.0
T_5.30x10 cm	33.33^{a-e}	44.67^{cde}	87.00	83.33	85.2
T_6. 30x12.5 cm	34.27^{a-d}	43.00^{cde}	85.67	83.67	84.7
Double planting pattern					
T_7. 40 x5 cm	28.03^{f}	40.33^{e}	86.33	83.00	84.7
T_8. 40 x7.5 cm	29.90^{de}	42.67^{cde}	86.33	83.00	84.7
T_9. 40 x10 cm	30.97^{cdef}	43.33^{cde}	86.33	84.00	85.2
T_{10}. 40 x12.5 cm	36.17^{ab}	52.33^{ab}	87.33	83.33	85.3
T_{11}. 50 x5 cm	29.20^{ef}	42.00^{de}	86.33	83.00	84.7
T_{12}. 50 x7.5 cm	31.60^{c-f}	42.67^{cde}	86.67	82.33	84.5
T_{13}. 50 x10 cm	33.83^{a-e}	46.67^{a-e}	88.00	82.33	85.2
T14. 50x12.5 cm	34.60^{a-d}	45.33^{b-e}	87.67	83.00	85.3
CV (%)	7.57	8.45	1.90	1.72	
Level of significance	*	*	NS	NS	

Means followed by the same letter (s)in the same column are not significantly different at 5% probability level according to Duncan's

Multiple Range Test; NS= non-significant, *=significance at 5%.

Yield Parameters

Mean bulb size

There was significance difference (P<0.5) among the treatments of spacing on bulb size of onion. The highest bulb size was recorded at the spacing of 50 x 12.5 cm followed by 50 x 10 cm in double planting manner. The smallest bulb size was also recorded at double planting of 40 x 5 cm in both years (Table 3). In agreement with the present result, Yemane *et al*. (2013) [14] reported that as the intra-row spacing increased from 5 to 10 cm, the percentage of large size bulbs increased from 9.3 to 20.3. Similarilly, Jilani *et al*. (2009) [7] reported that significant. Difference with the plant spacing appeared bigger at the wider spacing.

Average bulb weight

As indicated in (Table 3) spacing did not significance affected the bulb weight of onion in the year 2016 but significantly influenced by plant spacing in the year 2017. Accordingly, the highest average bulb weight (87.90 g) was produced at double spacing of 50 x 10 cm, while the lowest average bulb weight (72.12 g) was observed in single planting of 30 x 7.5 cm. similarly Yemane *et al*. (2013) [14] founded that the highest average bulb weight increase as the interspacing increases from 5 cm to 10 cm. This result also confirms Aliyu *et al*. (2008) [1] who noticed that densely populated plants produced lower bulb weight as compared to thinly populated plants. Similarly, Jilani *et al*. (2009) [7] also reported that the highest fresh bulb weight was observed at the wider intra spacing.

Table 3: Mean bulb size and bulb weight for onion as influenced by plant spacing under irrigation

Treatments	Bulb size (cm)		Mean	Average bulb weight (g)		Mean
	2016	2017		2016	2017	
Single planting pattern						
T_1. Flat planting of 20x10 cm	5.27^{bcde}	5.2^{bcdef}	5.24	76.00	73.8^{de}	74.90
T_2. 40x10 cm	5.73^{abcd}	5.57^{bcd}	5.65	80.67	87.2^{ab}	83.94
T_3.30x5 cm	5.43^{bcd}	4.9^{defg}	5.17	74.67	74.9^{cde}	74.79
T_4. 30x7.5 cm	5.33^{bcde}	5.3^{bcde}	5.32	73.33	70.9^{e}	72.12
T_5.30x10 cm	5.47^{bcd}	5.0^{cdefg}	5.24	82.00	76.9^{bcde}	79.45
T_6. 30x12.5 cm	5.80^{abc}	5.63^{bc}	5.72	86.33	83.7^{abcd}	85.02
Double planting pattern						
T_7. 40 x5 cm	4.47^{e}	4.36^{g}	4.42	78.33	75.43^{cde}	76.88
T_8. 40 x7.5 cm	5.17^{bcde}	4.60^{efg}	4.89	74.00	74.43^{cde}	74.22
T_9. 40 x10 cm	5.57^{abcd}	4.83^{efg}	5.20	79.00	76.8^{bcde}	77.90
T_{10}. 40 x12.5 cm	5.40^{bcd}	4.83^{efg}	5.12	78.67	77.8^{bcde}	78.24
T_{11}. 50 x5 cm	4.83^{de}	4.53^{fg}	4.68	77.33	71.20^{es}	74.27
T_{12}. 50 x7.5 cm	5.13^{cde}	5.67^{b}	5.40	81.33	85.33^{ab}	83.33
T_{13}. 50 x10 cm	6.06^{ab}	6.3^{a}	6.18	87.67	88.13^{ab}	87.90
T1$_4$. 50x12.5 cm	6.37^{a}	6.4^{a}	6.39	82.00	89.67	85.84
CV (%)	8.58	7.08		8.68	7.77	8.23
Level of significance	**	*		**	NS	

Means with the same letter (s) in the same column are not significantly different; *= Significant at 5% probability level; **= significant at 1% probability level; NS= non-significant

Total bulb yield and marketable bulb yield

Effect of the intra and inter spacing showed significance (P< 0.05) difference on the bulb yield of onion in both years (Table 4). Accordingly, the highest total bulb yield of 21.28 ton ha-1 and marketable bulb yield of 20.60 ton ha-1 was recorded at the spacing of 40 x 5 cm followed by single planting 20 x 10 cm (20.99 ton ha-1) for total bulb yield and 40 x 7.5 cm (19.69 ton ha-1) for the marketable bulb yield in 2016 in double planting manner (Table 4).

Bulb onion produced with a spacing of 40 x 5 cm was increased by 45.25% as compared to bulb yield produced with spacing of 30 x 12.5 cm (14.65 ton ha-1). Similarly, the highest total bulb yield and marketable bulb yield 32.92 and 31.30 ton ha-1 was recorded at the spacing of 40 x 5 cm in 2017 with double planting manner. Minimum total bulb yield (18.68) was obtained from double planting of 50 x 12.5 cm in 2016. The highest total bulb yield gave 76.23% yield advantage over the lowest ones. The lowest total bulb yield production would be due to extreme wider spacing at which the required population ha-1 could not be accommodated; and this result in low production of total bulb yield because of low population density. Moreover, the pooled mean result indicated that double planting inters and intra spacing of 40 and 5 cm, respectively gave high yield of onion in both the total and marketable bulb yield. The current result was found consistent with Jan *et al*. (2003) [8] reported the highest total bulb yield (549.90 kg ha-1) was obtained at a closer spacing, whereas the lowest total bulb yield was recorded from a wider spacing. Similarly, Yemane *et al*. (2013) [14] reported that as intra-row spacing increased from 5 to 10 cm, total bulb yield in tons ha-1 decreased. Significantly, the highest total bulb yields of 36.14 and 33.82 tons ha-1were recorded at 5 and 7.5 cm intra-row spacing, respectively. An intra-row spacing of 10 cm showed the lowest total bulb yield (28.51 tons ha-1).

Unmarketable Yield

Significance difference was observed on unmarketable yield (P<0.05) by the inter and intra row spacing in both 2016 and 2017 irrigation season. The highest unmarketable yield (2.25 ton ha-1) was recorded at 50 x 5 cm in double planting manner in 2016 cropping season. Whereas the lowest unmarketable yield (0.87 ton ha-1) was recorded at 30 x 12.5 cm in single planting manner. In 2017 cropping season the maximum unmarketable bulb yield (2.72 ton ha-1) was observed at the flat bed of 20 x 10 cm. Moreover, the pooled mean result indicated that the highest unmarketable yield was observed at flat planting of 20 x 10 cm inter and intra row spacing (Table 4). This is for the reason that flatbed planting resulted in decayed bulbs and large sized bulbs which was unwanted in the local market.

This finding was contrast with the result of other workers (Yemane *et al*., 2013; Habtamu *et al*., 2016) [14, 5] who concluded that plant density has an impact on unmarketable bulb size.

Table 4: Mean total bulb yield, marketable bulb yield and un marketable bulb yield for Onion as affected by plant spacing under irrigation

Treatments	Total bulb yield (t ha^{-1})			Marketable bulb yield (t ha^{-1})			Unmarketable bulb yield (t ha^{-1})		
	2016	2017	**Mean**	2016	2017	**Mean**			**Mean**
Single planting pattern									
T_{1}. Flat planting of 20x10 cm	20.99^{a}	28.80^{abc}	24.90^{ab}	9.07^{abc}	26.09^{a-c}	22.58^{a-d}	1.92^{a}	2.72^{a}	2.32^{a}
T_{2}. 40x10 cm	16.72^{abc}	16.72^{abc}	18.22^{de}	5.73^{bcd}	17.78^{d}	16.75^{e}	0.99^{d}	1.95^{b}	1.47^{bcd}
T_{3}.30x5 cm	19.17^{abc}	30.47^{ab}	24.82^{ab}	8.02^{a-d}	28.61^{ab}	22.32^{ab}	1.15^{cd}	1.86^{b}	1.5^{bc}
T_{4}. 30x7.5 cm	18.03^{abc}	24.93^{cde}	21.48^{b-e}	16.30^{a-d}	23.69^{bcd}	20.00^{b-e}	1.72^{bcd}	1.24^{cd}	1.48^{bc}
T_{5}.30x10 cm	16.18^{bc}	20.07^{de}	18.13^{de}	15.13^{cd}	19.08^{cd}	17.11^{e}	1.05^{cd}	0.99^{d}	1.02^{de}
T_{6}. 30x12.5 cm	14.65^{c}	19.37^{de}	17.01^{e}	13.79^{d}	18.42^{cd}	16.10^{e}	0.87^{d}	0.96^{d}	1.91^{e}
Double planting pattern									
T_{7}. 40 x5 cm	21.28^{a}	32.92^{a}	27.01^{a}	20.60^{a}	31.30^{a}	25.95^{a}	0.67^{d}	1.62^{bc}	1.15^{cde}
T_{8}. 40 x7.5 cm	20.96^{a}	27.26^{a-d}	24.11^{abc}	19.69^{ab}	25.91^{abc}	22.80^{abc}	1.27^{bcd}	1.35^{cd}	1.31^{b-e}
T_{9}. 40 x10 cm	18.13^{abc}	22.50^{cde}	20.31^{cde}	16.23^{bcd}	21.38^{bcd}	18.81^{cde}	1.9^{ab}	1.16^{d}	1.51^{bc}
T_{10}. 40 x12.5 cm	20.56^{ab}	20.42^{de}	20.49^{b-e}	19.32^{abc}	19.41^{cd}	19.37^{b-e}	1.24^{cd}	1.00^{d}	1.12^{cde}
T_{11}. 50 x5 cm	20.86^{a}	22.85^{b-e}	21.86^{bcd}	18.61^{abc}	21.70^{bcd}	20.16^{b-e}	2.25^{a}	1.14^{d}	1.7^{b}
T_{12}. 50 x7.5 cm	18.89^{abc}	20.56^{de}	19.72^{cde}	17.74^{a-d}	19.54^{cd}	18.64^{de}	1.15^{cd}	1.02^{d}	1.08^{cde}
T_{13}. 50 x10 cm	19.10^{abc}	19.72^{de}	19.41^{de}	17.97^{a-d}	18.75^{cd}	18.36^{e}	1.13^{cd}	0.97^{d}	1.05^{cde}
T_{14}. 50x12.5 cm	17.01^{abc}	18.68^{e}	17.85^{de}	16.00^{bcd}	17.76^{d}	16.88^{e}	1.01^{cd}	0.92^{d}	0.97^{e}
CV (%)	12.45	11.5		12.8	17.9	11.00	27.4	19.2	18.0
Level of significance	*	**		*	**	*	*	*	*

Conclusions

Optimum plant spacing has a promising impact in increasing the productivity and production of Onion. The findings of the present study showed that plant height, bulb size, total bulb yield and above ground dry biomass yield were significantly affected by inter and intra spacing of Onion. The tallest plant height was obtained at spacing of single planting 40 x 10 cm. The maximum total bulb yield and above ground dry biomass yield were obtained at the double planting of 40 x 5 cm in both years as compared to the other treatments. It is, therefore, concluded that spacing of double planting 40 x 5 cm can be recommended for the growers in the study area as the total bulb and marketable bulb was high compare to the other treatments to increase Onion productivity.

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