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Original Research

Performance of Two Onion (*Allium cepa* L.) Cultivars under Two Different Planting Systems in Calcareous Soil

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ABSTRACT

Onion is one of the most valuable vegetables all over the world. It prefers loose, well drained loamy soils rich in organic matter. In calcareous soils, the growth and yield of onion crop is low. The objective of the present investigation was to study the performance of two onion cultivars (Super Selection and Nasarpuri) in calcareous soil by adopting proper planting system. The crop was planted under two planting systems i.e. flat bed and ridge system. Significantly higher leaf weight was recorded on ridges than flat beds. Root weight was significantly higher in cultivar Nasarpuri than Super Selection. Moreover, plants on ridges attained more root weight than those grown on flat beds. Larger equatorial and polar diameters of bulbs were recorded in Super Selection, and also in the plants grown on ridges. The bulbs harvested from ridges had higher moisture content, than those harvested from flat beds. The neck diameter was significantly greater in Nasarpuri as compared with Super Selection. Number of splited bulbs and number of splits in bulbs were not affected by the cultivars and planting systems. The highest bulb weight was recorded from ridges in cv. Nasarpuri, followed by Super Selection. The significantly greater economic yield, biological yield and harvest index were obtained from the plants grown on ridges. Leaf weight showed significant association with neck diameter, bulb weight, economic yield and biological yield. Bulb weight showed significant correlation with economic yield, biological yield and harvest index.

Keywords: *Biological yield, bulb size, economic yield, flat beds, ridges, trait association.*

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INTRODUCTION

Onion (*Allium cepa* L.) belongs to *Alliaceae* family. Its genus is *Allium* which contains more than 200 species. Onion is one of the most valuable vegetables and condiments all over the world (Pathak, 2000). Generally, open pollinated cultivars and hybrids are Pathak_2000cultivated due to its allogamous nature. The development of onion bulb may vary in size, color and shape due to selection of cultivar and day length requirements. A relatively high temperature and long photoperiod are required for bulb formation; temperature is of immense importance than day length (Ikeda et al., 2019).

Onion is native to Asia. USA. Romania, Japan, Italy and Turkey are major countries producing onion crop (Mohammadi et al., 2010). Onion is a biennial plant with a specific smell (Job et al., 2016). Mature bulb is commonly used as salad, vegetable and condiment round the year. It is also used in soups, kababs, meat dishes, rice, sandwiches and beans. Moreover, it is also used in pickles, curries and chutnies etc. (Sohail et al., 2011). Onion is acknowledged as medicinal herb worldwide (Zahid et al., 2008). Different human health issues i.e. high cholesterol, heart diseases, diabetes, obesity, anemia, diarrhea, cancer and depression can be controlled with onion consumption (Basit and Shera, 2008; Nicastro et al., 2015). Metabolic syndrome, dyslipidemia and obesity are major health issues very common in rural areas (Zubair et al., 2009). Traditional medicines are cheaper source of medication as compared to modern medicines for poor people (Azaizeh et al., 2010). Onion has dermatological, hypolipidemic, antimicrobial and antitumor properties due to presence of sulfur compounds (Sarwar et al., 2011).

Onion is a cool season vegetable crop and grows well under mild climate without extreme heat or cold or excessive rainfall (Shah et al., 2012). The young seedlings can withstand freezing temperature. Onion grows well in loose, well-drained and loamy soils rich in humus (Tantawy and Beik, 2009). However, in calcareous soils, its growth and yield are adversely affected. Calcareous soils are rich in calcium carbonate, low in organic matter and have high pH (7.5-8.5). The availability of different nutrients i.e. phosphorus, potassium and zinc are greatly depressed due to calcium carbonate and high pH. Onion is considered as long day plant for bulb formation as well as its development. However, cultivars may vary in their response to length of day (Jilani et al., 2010). Bulb size and its weight are important traits which are directly involved for higher crop yield (Tantawy and Beik, 2009). Onion yield is mainly influenced through numerous factors i.e. climatic conditions, soil conditions, seed quality, seedling age, spacing, planting date,

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planting system, fertilizer application and other cultural practices (Mirshekari and Mobasher, 2006).

In Pakistan, onion production is still very poor as compared to other countries of the globe. Planting system and selection of unsuitable cultivars are critical factors especially in calcareous soils that limit the onion production. Planting system greatly influenced onion yield even within a particular cultivar (Rizk, 1997). The adoption and management of proper planting system in problem soils for onion production is need of time. Therefore, evaluation of high yielding planting system is needed. The major disadvantage of flat sowing method is excessive nitrogen leaching, poor aeration and disturbance of top soil. On the other hand, ridge system is efficient method to save water, enhance fertilizers efficiency, resulting in higher onions yield (Aklilu and Dessalenge, 2015). The performance of onion cultivars on ridges was superior then flat beds (Getahun, 2016). Hence, the aim of the present study was to improve the yield of onion cultivars in calcareous soil of Multan (Pakistan) area by adopting a suitable planting system.

MATERIALS AND METHODS

Experimental site

Current experiment was conducted at the Vegetable Research Area of Department of Horticulture Bahauddin Zakariya University, Multan during the year 2018 - 2019. Monthly temperature and rainfall data were collected from sowing to harvesting as presented in Figures 1 & 2. Current study was conducted in calcareous soil. Physico-chemical properties (0-15 cm depth) of the soil taken from experimental field were; texture loamy, EC 5.58 dSm^{-1}, pH 8.4, organic matter 0.76%, available potassium 205 ppm and available phosphorus 10.4 ppm.

Land preparation and planting

Land was prepared by ploughing and planking to a fine tilth. Flat beds were made about 2 m long and 2 m wide. Ridges were prepared 60 cm apart. Line spacing in flat beds was 30 cm. The area under each treatment was equal. Experiment was laid out according to Randomized complete block design (RCBD) with two factors i.e. cultivars and planting systems and three

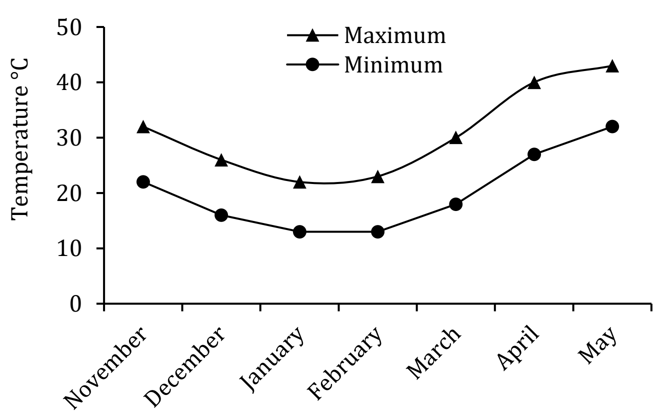

Figure 1: The maximum and the minimum temperatures from November 2018 - May 2019 at the experimental site.

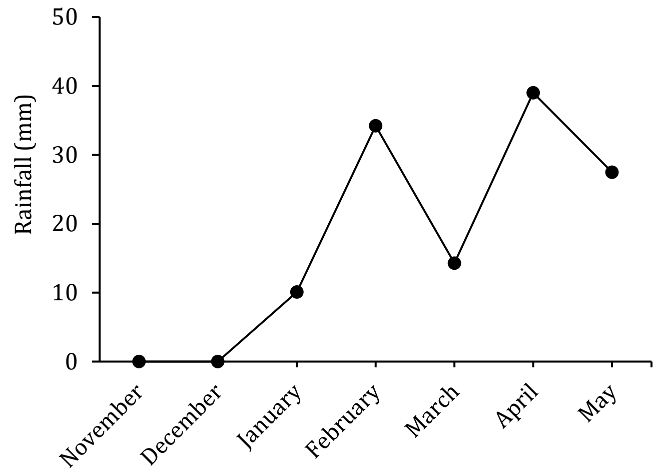

Figure 2: The rainfall from November 2018 - May 2019 at the experimental site.

replications. Seedlings (about 15 cm tall) were purchased from local market and transplanted on 19th November 2018 at a distance of 10 cm in flat beds and ridges. The seedlings were transplanted on both sides of ridges. After transplanting the seedlings, field was irrigated immediately. Crop was harvested on 6th May 2019.

Crop maintenance

All recommended cultural practices were followed according to crop requirement. Subsequent irrigations were applied regularly on need basis. Continuous weeding by hand was performed to keep the beds and ridges clean. Fertilizers were applied at the recommended dose i.e. nitrogen and phosphorus @ 50 kg/ha each (Shah et al., 2012).

Data recorded

Ten plants were randomly selected from each treatment in each replication and data on different growth, bulb quality and yield related traits were recorded. Fresh bulb, leaf and root weights (g) were estimated using digital weighing balance (WT6002-D). Equatorial, polar and neck diameters of bulbs (mm) were measured through a digital vernier caliper (IKKEGOL). Bulbs were dried in a Hotbox oven at 70 °C till constant dry weight. Bulb moisture content (%) was measured from below listed formula.

$$\text{Moisture content (\%)} = \frac{\text{Bulb weight before drying} - \text{Bulb weight after drying}}{\text{Bulb weight before drying}} \text{ x } 100$$

Number of splited bulbs and number of splits in bulb were also counted. Economic yield ($t\ ha^{-1}$) was determined by taking the fresh weight of the bulbs. Fresh leaf, bulb and root weights were used to estimate biological yield ($t\ ha^{-1}$). Harvest index (%) was determined from below listed formula.

$$\text{Harvest index (\%)} = \frac{Economic\ yield}{Biological\ yield} x\ 100$$

Statistical analysis

Analysis of variance was used to analyze the collected data of onion crop to evaluate the performance of two different cultivars sown under two different systems using a computer software Statistix 8.1 (Tallahassee Florida, USA). Mean values were separated with LSD test at 5% level of probability. Trait association analysis was carried out through R software.

RESULTS

Planting systems significantly affected onion leaf weight. However, the cultivars and interaction of cultivars and planting systems did not have any significant effect on the parameter (Table 1). The highest leaf weight was recorded from the plants grown on ridges (18.77 g) as compared to those on flat beds (16.42 g) (Table 2). Cultivars significantly differed for root weight of onions. Similarly, planting system had significant influence on the parameter under study. However, the interaction means of cultivars and planting systems did not differ significantly from each other for onion root weight (Table 1). Means values indicated that significantly higher root weight was recorded in cultivar Nasarpuri (3.06 g) as compared with Super Selection (2.34 g). Moreover, the means of planting systems showed that significantly higher root weight was attained in plants grown on ridge (3.12 g) as compared to those grown on flat beds (2.28 g) (Table 2). Cultivars and planting system individually showed significant differences for equatorial and polar diameter. However, interaction between cultivars and planting system showed non-significant differences among their means (Table 1). Bulbs of Super Selection (58.94 mm) had significantly greater equatorial diameter than Nasarpuri (53.34 mm). Regarding the planting systems, significantly larger equatorial diameter was recorded in bulbs harvested from ridges (64.52 mm) as compared to those harvested from flat beds (47.76 mm). Mean values indicated that significantly greater polar diameter was recorded in cultivar Nasarpuri (64.52 mm), than in Super Selection (59.78 mm). Planting systems showed that significantly greater polar diameter of bulbs was recorded from ridges (65.82 mm) as compared with flat beds (58.49 mm) (Table 2).

Regarding the moisture content of bulb, cultivars showed non-significant difference, while planting systems showed significant difference among their means. Moreover, interactive effect of cultivars and planting systems was non-significant (Table 1). Significantly higher moisture content was recorded from those bulbs which were harvested from ridges (36.13%) than those from flat beds (20.08%) (Table 3). Regarding the neck diameter of bulbs, cultivars showed significant difference, while non-significant difference was observed between the planting systems. Moreover, the interaction between cultivars and planting systems also showed significant differences among their means (Table 1). Mean values indicated that significantly larger neck diameter was recorded in Nasarpuri (22.88 mm), when compared with neck diameter of Super Selection (18.90 mm). Moreover, interaction between cultivars and planting systems revealed that significantly greater neck diameter was measured in cultivar Nasarpuri from ridge (27.23 mm), while the minimum in Super Selection from ridges (17.36 mm), followed by in Nasarpuri on flat beds (18.53 mm) and Super Selection (20.44 mm) on flat beds (Table 3). Statistical analysis exhibited that the effects of cultivars and planting systems and their interaction were non-significant for number of splited bulbs and number of splits in bulb (Table 1). This indicated that the cultivars studied did not differ for splitting of bulbs. Further the planting systems adopted have no role in splitting of onion bulbs. Further, number of splits in onion bulbs was not affected by the cultivars used and planting systems adopted (Table 3).

Statistical analysis of the data for fresh bulb weight depicted that the cultivars showed non-significant difference. However, the difference between planting systems was statistically significant. Moreover, interaction of cultivars and planting systems also showed significant differences among their means (Table 1). Mean values indicated that significantly greater fresh bulb weight was recorded from ridges (118.16 g), as compared with flat beds (92.23 g). The interaction of cultivars and planting systems showed that the highest bulb weight was recorded in cultivar Nasarpuri (123.67 g) planted on ridges followed by Super Selection (112.66 g) also planted on ridges, while the lowest was in Nasarpuri (86.46 g) on flat beds, followed by Super Selection (98.01 g) also from flat beds (Table 4). Regarding the effect of cultivars, economic yield, biological yield and harvest index showed non-significant differences, while the effect of planting systems on all the three parameters was significant. Moreover, interactive effect of cultivars and planting system was significant on economic yield and biological yield and non-

Table 1: Statistical analysis (LSD values) of different growth, bulb quality and yield attributes of two onion cultivars grown under different planting systems.

Trait	Cultivars	Planting systems	Cultivars × Planting systems
Leaf weight (g)	0.10^{ns}	10.58*	2.11^{ns}
Root weight (g)	6.24*	8.70*	0.29^{ns}
Equatorial diameter of bulb (mm)	7.18*	64.42**	2.23^{ns}
Polar diameter of bulb (mm)	6.17*	14.73**	0.53^{ns}
Moisture content of bulb (%)	0.05^{ns}	16.25**	0.28^{ns}
Neck diameter of bulb (mm)	8.65*	4.30^{ns}	18.91**
Number of splited bulbs	0.4055^{ns}	0.80^{ns}	3.20^{ns}
Number of splits in bulb	0.37^{ns}	0.37^{ns}	3.37^{ns}
Fresh bulb weight (g)	0.00^{ns}	32.87**	6.22*
Economic yield (t ha^{-1})	0.00^{ns}	32.84**	6.21*
Biological yield (t ha^{-1})	0.00^{ns}	36.05**	9.49*
Harvest index (%)	0.69^{ns}	17.87**	0.32^{ns}

*ns = non-significant, * = significant at p = 0.05, and ** = significant at p = 0.01.*

Table 2: Growth traits of onion as affected by cultivars and planting systems.

Cultivars	Leaf weight (g)			Root weight (g)			Equatorial diameter of bulb (mm)			Polar diameter of bulb (mm)		
	Flat beds	Ridges	Mean	Flat beds	Ridges	Mean	Flat beds	Ridges	Mean	Flat beds	Ridges	Mean
Super Selection	17.06 a	18.36a	17.71 A	1.84 a	2.84 a	2.34 B	49.00 a	68.88 a	58.94 A	56.81 a	62.75 a	59.78 B
Nasarpuri	15.78 a	19.18a	17.48 A	2.71 a	3.41 a	3.06 A	46.52 a	60.17 a	53.34 B	60.17 a	68.88 a	64.52 A
Mean	16.42 B	18.7A		2.28 B	3.12 A		47.76 B	64.52 A		58.49 B	65.82 A	

** Means sharing similar letter(s) in a group are statistically non-significant at p = 0.05 (LSD test).*

Table 3: Bulb quality traits of onion as affected by cultivars and planting systems.

Cultivars	Moisture content of bulb (%)			Neck diameter of bulb (mm)			Number of splited bulbs			Number of splits in bulb		
	Flat beds	Ridges	Mean	Flat beds	Ridges	Mean	Flat beds	Ridges	Mean	Flat beds	Ridges	Mean
Super Selection	21.58 a	35.52 a	28.55 A	20.44 b	17.36 b	18.90 B	0.33 a	0.00 a	0.17 A	0.33 a	0.00 a	0.17 A
Nasarpuri	18.58 a	36.75 a	27.66 A	18.53 b	27.23 a	22.88 A	0.00 a	1.00 a	0.50 A	0.00 a	0.67 a	0.33 A
Mean	20.08 B	36.13 A		19.49 A	22.30 A		0.17 A	0.50 A		0.17 A	0.33 A	

** Means sharing similar letter(s) in a group are statistically non-significant at p = 0.05 (LSD test).*

Table 4: Yield traits of onion as affected by cultivars and planting systems.

Cultivars	Fresh bulb weight (g)			Economic yield (t ha^{-1})			Biological yield (t ha^{-1})			Harvest index (%)		
	Flat beds	Ridges	Mean	Flat beds	Ridges	Mean	Flat beds	Ridges	Mean	Flat beds	Ridges	Mean
Super Selection	98.01 bc	112.66 ab	105.33 A	32.67 bc	37.55 ab	35.11 A	39.58 bc	44.01 ab	41.87 A	82.53 a	85.29 a	83.90 A
Nasarpuri	86.46 c	123.67 a	105.06 A	28.82 c	41.22 a	35.02 A	34.99 c	48.75 a	41.79 A	82.38 a	84.48 a	83.43 A
Mean	92.23 B	118.16 A		30.74 B	39.39 A		37.28 B	46.38 A		82.45 B	84.88 A	

** Means sharing similar letter(s) in a group are statistically non-significant at p = 0.05 (LSD test).*

significant for harvest index (Table 1). The highest economic yield (39.39 t ha^{-1}), biological yield (46.38 t ha^{-1}) and harvest index (84.88%) were calculated from ridges. Moreover, the lowest economic yield (30.74 t ha^{-1}), biological yield (37.28 t ha^{-1}) and harvest index (82.45 %) were calculated from flat beds (Table 4). The interaction of cultivars and planting systems showed that the highest economic yield was recorded in cultivar Nasarpuri (41.22 t ha^{-1}) planted on ridges followed by Super Selection (37. 55 t ha^{-1}) also planted on ridges, while the lowest was in Nasarpuri (28.82 t ha^{-1}) on flat beds, followed by Super Selection (32.67 t ha^{-1}) also from flat beds (Table 4). The interaction of cultivars and planting systems showed that the highest biological yield was recorded in cultivar Nasarpuri (48.75 t ha^{-1}) planted on ridges followed by Super Selection (44.01 t ha^{-1}) also planted on ridges, while the lowest was in Nasarpuri (34.99 t ha^{-1}) on flat beds, followed by Super Selection (39.58 t ha^{-1}) also from flat beds (Table 4).

Leaf weight showed significant association with neck diameter (0.78), bulb weight (0.73), economic yield (0.71) and biological yield (76). A significant association was recorded between number of splited bulbs and number of splits in bulbs (0.93). Bulb weight showed significant association with economic yield (0.99), biological yield (0.99) and harvest index (83). Moreover, biological yield also showed significant association with harvest index (0.79) as shown in Figure 3.

DISCUSSION

The highest leaf and root weights were achieved from the plant grown on ridges than on those harvested from flat beds. Further the cultivars also differed in root weight. Similar results about variability in leaf and root weights among different genotypes and planting systems was recorded in an earlier work (Rizk, 1997). The higher moisture level and nutrients availability in loose soil of ridges significantly improved root growth which resulted in enhanced leaf weight (Gessesew et al., 2105). The cultivar Super Selection had more equatorial diameter, while Nasarpuri had more polar diameter. These differences in their diameters may be due to difference between their genetic make-up (Khan et al., 2003). Bulb size is considered as important trait that directly affects bulb yield per unit area. Thus, better root and leaf growth improved bulb size and this increase in bulb size directly enhanced onion yield (Verma et al., 1994). Current study results are in agreement with previous findings who recorded higher bulb size in acid soils (Roy et al., 2016).

The highest moisture content was observed from onion bulbs harvested from ridges as compared to those from flat beds. Flat beds had low moisture level due to compacted soil layer as compared to ridges. Hence, the highest moisture content of bulb was recorded from ridges (Getahun, 2016). However, cultivars did not differ in moisture level of bulbs. In the present study, variation in neck diameter was recorded in two onion cultivars. Neck diameter was larger in cultivar Super Selection as compared to Nasarpuri. So, the results of neck diameter are in accordance with the findings of earlier worker, who conducted that the neck diameter was based on climatic conditions, management practices and cultivars genetic make-up (Abdissa et al., 2011). Two onion cultivars studied and two planting systems adopted did not exhibit any variation in number of

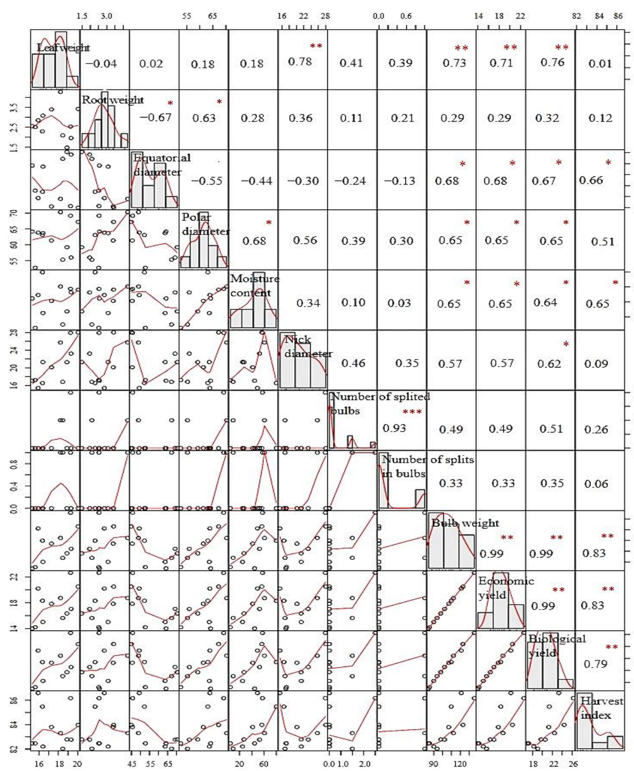

Figure 3: Correlation matrix among growth, bulb quality and yield related traits of onion.

splited bulbs and number of splits in bulbs. However, it has been confirmed that the adopted planting systems in the present study has no role in splitting of onion bulbs as in previous work (Aklilu and Dessalenge, 2015; Getahun, 2016).

Significantly greater bulb weight was recorded from ridges as compared to flat beds. In ridges, soil is enough loose which provides better conditions for development of onion bulbs. Excess of flood water from rain can also be easily drained from ridges, while flat beds have poor drainage system due to compact soil layer. Bulb weight is an important trait that directly affects bulb yield per unit area. Thus, the increase in bulb weight resulted in higher onion yield. Current study results are in agreement with previous finding who obtained higher bulb weight from ridges (Dawar et al., 2007; Aklilu and Dessalenge, 2015). The means of planting systems showed that significantly higher economic yield, biological yield and harvest index was attained in plants grown on ridge. Soil conditions was the major aspect for attaining higher crop yield (Ikeda et al., 2019). Higher biological yield in case of ridge planting was attributed to higher root, leaf and tuber weight in this planting system.

Trait association analysis was carried out to identify the traits that were the major cause of variation in cultivars. It is an effective and useful technique to examine the huge set of information in multivariate data (Anjum et al., 2018). Plant breeders have greater interest in trait association analysis for development of higher yielding cultivars. Correlation studies were also carried in numerous other crops (Anjum et al., 2018; Sarwar et al., 2019). Improved root and leaf growth directly increase equatorial and polar diameter, bulb weight (economic yield) and biological yield of onion cultivars. Bulb weight, equatorial and polar diameter are yield contributing traits of onions. Similar correlation among numerous traits was recorded in previous research work (Gurjar and Singhania, 2006). Trait association among numerous traits was due to pleiotropic effect of various genes (Islam et al., 2019).

CONCLUSION

Onion is one of the most valuable vegetables and condiments all over the world. There is urgent need of time to work on yield improvement programs. Conclusively, the performance of both the onion cultivars studied was almost similar in calcareous soil except in some morpho-physical parameters due to their genetic make-up. However, the ridge planting system performed better as compared to flatbed system.

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