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Effect of plant density on growth and yield attributes of different onion varieties

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ABSTRACT

An investigation was carried out at the Farm of Bangladesh Institute of Nuclear Agriculture, Mymensingh, during the period from November, 2018 to June, 2019 to study the effect of plant spacing on growth, yield and yield contributing characteristics of different onion varieties. There were three levels of plant spacing viz. 10x10 cm, 20x15 cm and 20x10 cm and three varieties viz Binapiaz-1, Binapiaz-2 and Taherpuri in rabi season and in kharif plant spacing viz. 20x10 cm, 20x15 cm, 30x10 and 30x20 cm and two varieties viz Binapiaz-1 and Binapiaz-2 were used for the study. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The plant spacing showed significant effects on most of the parameters studied among the varieties. It is clearly revealed that the wider spacing gave the highest result in bulb diameter (80.2 and 40.1 mm) in both kharif-1 and rabi season; but the closer spacing produced highest yield of bulbs (9.4 and 6.93 t ha^{-1}). Significant effect was found on the growth, yield components and yield of bulb among the three varieties. The highest bulb yield (7.6 and 5.02 t ha^{-1})was produced from Binapiaz-1 in both rabi and kharif season and the lowest (6.1 t ha^{-1}) was in Taherpuri cultivar in rabi season while Binapiaz-2 gave lowest yield (4.55 t ha^{-1}) in kharif season. The combined effect of plant spacing and variety demonstrated a significant variation. In rabi season, highest yield (9.3t ha^{-1}) was found in closer spacing i.e 10x10 cm in Binapiaz-1 followed by Binapiaz-2 (8.7t ha^{-1}) while in kharif season, highest yield (6.95t ha^{-1}) was found from Binapiaz-1 with 10x10 cm plant density. It was found that Binapiaz-1 performed better in respect of yield and other parameters in closer plant arrangement both in rabi and kharif season.

INTRODUCTION

Onion (*Allium cepa* L.) is an important bulbous crop of Alliaceae family believed to have its origin in Asia. It is grown throughout the world for its pungency and nutritive value as green vegetable as well as mature bulbs. Mostly it is annual for bulb production and biennial for seed production. In terms of world production, onion ranks second among the fifteen vegetable specified countries according to Food and Agriculture Organization (FAO). In Bangladesh, among the spices, onion ranks first in respect of area and production (BBS, 2016). It is used in all food preparations of our daily diet. The crop is also appreciated as condiments for flavouring foods. It contains high medicinal properties with adequate vitamin B, Vitamin C, iron and calcium (Vohora et al., 1974) and reduces the blood sugar by 25% (Mossa, 1985; Yawalkar, 1985). It is valued for its bulbs having characteristics odour, flavor, and pungency, which is due to the presence of a volatile oil-allyl-propyldisulphide. Onion is the richest source 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.

The yield of onion is very low (3.94 t/ha) in our country compared to the world average yield (17.00 t/ha), and it remained fairly static for the last five years (FAO, 2003). Total production of onion in Bangladesh is only 1.7million tons from an area of 0.17 million hectares (BBS, 2016) as against the estimated demand of 2.2million tons. This production of onion cannot fulfill our national demand. Onion production is greatly influenced by agronomic practices (Mondal et al., 2004).One of the major problems associated with its production is inappropriate agronomic practices used by farmers which have quite a great contribution to lowering crop yields. The growth and yield of cultivated crop plants are mainly influenced by two principle factors genetical and cultural or management factor. The first factor deals with various breeding techniques for the improvement in crop varieties. The second factor deals with agronomical practices, planting date, spacing, fertilizer, irrigation, cultivation, plant protection, weed control etc. Both these factors have been exploited by various research workers in respective fields with varied success. However, efforts are still continue in this direction to gain further higher and higher yields.

Spacing determines the plant density and is generally dependent upon the expected growth of a particular crop variety in a given agro-climatic region. Therefore, optimum plant population is one of the important factors for optimum utilization of solar energy and soil nutrients to increase the yield per

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hectare of onion crop, where only single underground bulb is produced per plant. Higher plant population can be achieved by reducing the distance between two rows or between two plants within the row. Hence, the use of proper geometry to get appropriate plant stand is a prerequisite for higher crop yield per unit area.

Total bulb yield can be increased as population density increase (Kantona et. al., 2003). Several researchers in many countries have shown that varieties and plant spacing had profound effects on the growth and yield of onion (Bhonden et. al., 1995, Kumar et. al., 1998 and Pandey et. al., 1991). Yemane et al. (2014) reported the limited use of improved seeds and fertilizers by small scale farmers. Quality and yield of particular onion variety is greatly affected by planting density even if grown in the same environment (Saud et. al. 2013). Proper spacing ensures optimum plant growth through adequate utilization of moisture, light, spacing and nutrients (Zubeldia et. al., 2003). Therefore, the study was designed to determine the optimum plant population density for better plant growth and yield for different onion varieties and to determine the possible interaction of variety and plant population for growth and yield of onion.

MATERIAL AND METHODS

Experimental site

The experiment was conducted at the Research Farm of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh during November 2018 to June 2019 in rabi and kharif-1 season under subtropical condition. The experiment site lies about $24^0$72 N latitude and $90^0$43 E longitude at an altitude of 19 m above sea level. The area experiences rainfall that stretches from April to October with the main rainy season from June to early September. The area receives average rainfall between 100-500 mm with annual and maximum temperature ranging from 22 to 35^0C.

Varieties and Experiment

Three varieties viz. Binapiaz-1 and Binapiaz-2 (both winter and summer variety) and Taherpuri (local cultivar) with three level of plant spacing such as 10x10cm, 20x10cm and 20x15cm in rabi season and in kharif plant spacing viz. 20x10 cm, 20x15 cm, 30x10 and 30x20 cm and two varieties viz Binapiaz-1 and Binapiaz-2 were included in this experiment. The experiment was laid out in Factorial Randomized Complete Block Design (RCBD) and replicated in thrice. The unit plot size was 5m×4m. Manures and fertilizers were applied at same doses and methods for each treatment, forty days old seedlings were used in this study. Other cultural practices such as gap filling, irrigation, weeding and pest management were done as and when required. After being matured bulbs were harvested at same day for each treatment and curing was done for couple of days.

Data collection and analysis

The observation was made on the following parameters plant height (cm), number of leaves per plant, bulb diameter (mm), neck diameter (mm), leaf fresh weight (gm^{-2}), leaf dry weight (gm^{-2}), bulb fresh weight (gm^{-2}), bulb dry weight (gm^{-2}), yield of bulbs and crop duration (days). Data were collected from five randomly selected plants of each treatment. The collected data on various parameters under study were analyzed to find out the statistical significance of the experimental results. The means of all the treatments were calculated and analyses of variance for all the characters were performed by F test. The significance of the difference among the means was evaluated by Least Significant Difference Test (LSD).

RESULTS AND DISCUSSION

Spacing effect in Rabi season

Varietal effect

The growth, yield and yield contributing characters viz. plant height, number of leaves, bulb diameter, neck diameter, fresh weight and dry weights of foliage & bulb and yield of onion were significantly influenced by different varieties. The highest bulb diameter (79.60 mm) was found from Binapiaz-1 followed by Binapiaz-2 (77.80 mm) and the lowest (77.0 mm) was found from Taherpuri variety. Studied highest bulb yield (7.6 t ha^{-1}) was obtained from variety of Binapiaz-1. It is identical to the yield (7.0 t ha^{-1}) of Binapiaz-2. The lowest yield (6.1 t ha^{-1}) was produced by the variety Taherpuri. Identical performance was recorded in respect of plant height, number of leaves per plant, neck diameter of plant, leaf fresh weight, leaf dry weight, fresh weight of bulb, dry weight of bulb and total bulb yield. No significant variation was found between the varieties Binapiaz-1 and Binapiaz-2.

Spacing effect

Significantly the highest bulb diameter of plant (80.2 mm) was observed from the spacing 20x10 cm

followed by the spacing 20x15 cm (77.6 mm) and the lowest bulb diameter (76.5 mm) was observed from the spacing 10x10cm. The highest leaf fresh weight, leaf dry weight, bulb fresh weight and bulb dry weight (2933, 733, 1280 and 904) were counted from spacing 10cmx10 cm where the lowest result (1000, 250, 532 and 426) were found from the spacing 20x15 cm respectively. The yields of onion bulb per plot were increased with increase in number of plants per unit area. The yields of onion bulb per hectare were differed significantly by the treatments of different spacing. The highest bulb yield (9.0 t ha^{-1}) was weighted from the spacing 10x10 cm which was followed by 20x10 cm (6.0 t ha^{-1}) plant spacing and the lowest from the spacing 20x15 cm (4.3 t ha^{-1}).

Interaction effect of spacing and different cultivars

Significantly the highest bulb diameter (83.7 mm) was recorded from the variety Binapiaz-1 with 20x10cm followed by the variety Binapiaz-2 with spacing 20x10cm (80.9 mm). The lowest bulb diameter (75.2 mm) was obtained from the variety Taherpuri with 10x10 cm. The maximum (3200 $gm^{-2)}$ fresh weight of leaves was recorded from the variety Binapiaz-1 with spacing 10x10cm followed by variety Binapiaz-2 with 10x10cm. The minimum (967 gm^{-2}) bulb length was obtained from the variety Taherpuri with spacing 20x15 cm. The maximum fresh weight of bulb (1344 gm^{-2}) was obtained from the variety Binapiaz-2 with spacing 10x10cm followed by variety Taherpuri with spacing 20x15cm (1254 gm^{-2}). The minimum bulb fresh weight (415 gm^{-2}) was obtained from the variety Taherpuri with 20x15cm. The maximum bulb yield (9.3t ha^{-1}) was recorded from the variety Binapiaz-1 with spacing 10x10cm followed by the Binapiaz-2 with spacing 10x10 cm (8.7 t ha^{-1}). The minimum yield (3.9 t ha^{-1}) was recorded from the variety Taherpuri with spacing 20x15 cm. Bulb size and bulb weight decreased with the decrease in spacing. This result is in agreement with the findings of Gupta and Gaffer reported yield increased with the plant density up to certain level. Kumar et al., obtained the highest yield with a spacing of 15x10 cm. This accordance with Zubeldia and Gases obtained proper spacing ensures optimum plant growth through adequate utilization of moisture, light, spacing and nutrients.

Table 1: Determination of proper spacing of onion varieties in Rabi season

Treatments	Plant height (cm)	Leaf $plant^{-1}$ (no.)	Bulb diameter (mm)	Neck diameter (mm)	Leaf fresh weight (g m^{-2})	Leaf dry weight (g m^{-2})	Bulb fresh weight (g m^{-2})	Bulb dry weight (g m^{-2})	Bulb yield (t ha^{-1})	Crop duration (days)
Variety										
Binapiaz-1	39.2	7.4	79.6	10.5	1849	462	956	765	7.6	112
Binapiaz-2	40.4	7.3	77.8	10.1	1864	466	870	696	7.0	110
Taherpuri	41.4	6.9	77.0	10.5	1638	410	830	614	6.1	103
$LSD_{0.05}$	NS	NS	3.0	NS	171	43	106	85	0.8	-
Spacing										
10 cm×10 cm (S_1)	37.7	7.1	76.5	10.0	2933	733	1280	904	9.0	
20 cm×10 cm (S_2)	40.8	7.3	80.2	10.9	1419	355	744	595	6.0	
20 cm×15 cm (S_3)	42.5	7.2	77.6	10.3	1000	250	532	426	4.3	
$LSD_{0.05}$	NS	NS	3.0	NS	171	43	106	85	0.8	
Variety× Spacing										
$V_1 S_1$	37.1	7.4	78.4	10.4	3200	800	1141	933	9.3	
$V_1 S_2$	40.1	7.6	83.7	10.9	1379	345	780	624	6.2	
$V_1 S_3$	40.5	7.3	76.7	10.3	970	242	547	437	4.4	
$V_2 S_1$	37.6	7.2	76.0	9.4	3133	783	1344	1075	8.7	
$V_2 S_2$	40.5	7.6	76.5	10.8	1397	349	708	566	5.7	
$V_2 S_3$	43.2	7.2	80.9	10.2	1062	266	558	447	4.5	
$V_3 S_1$	38.5	6.7	75.2	10.3	2467	617	1254	1003	8.0	
$V_3 S_2$	41.9	6.9	80.5	11.0	1481	370	743	595	5.9	
$V_3 S_3$	43.8	7.1	75.3	10.4	967	242	492	394	3.9	
$LSD_{0.05}$	NS	NS	5.2	NS	296	74	183	146	1.5	
CV (%)	5.5	9.5	3.9	10.1	10	10	12	12	11.9	

* Significant at 5% level of probability; NS = Non significant

Spacing effect in Kharif-1 season

Varietal effect

The highest bulb diameter (39.40 mm) was found from Binapiaz-1 followed by Binapiaz-2 (38.90 mm) and Taherpuri cultivar was not used in this season because it's a winter variety. Studied highest bulb yield (5.02 t ha^{-1}) was obtained from variety of Binapiaz-1. It is identical to the yield (4.55 t ha^{-1}) of Binapiaz-2. Identical performance was recorded in respect of plant height, number of leaves per plant,

neck diameter of plant, leaf fresh weight, leaf dry weight, fresh weight of bulb, dry weight of bulb and total bulb yield. No significant variation was found between the varieties Binapiaz-1 and Binapiaz-2.

Spacing effect

Significantly the highest bulb diameter of plant (40.1 mm) was observed from the spacing 20x15 cm followed by the spacing 30x10 cm (39.4 mm) and the lowest bulb diameter (38.6 mm) was observed from the spacing 20x10cm. The highest leaf fresh weight, leaf dry weight, bulb fresh weight and bulb dry weight (1416, 354, 775 and 693.3) were counted from spacing 20x10 cm where the lowest result (470, 117, 254 and 235.7) were found from the spacing 30x20 cm respectively. The yields of onion bulb per plot were increased with increase in number of plants per unit area. The yields of onion bulb per hectare were differed significantly by the treatments of different spacing in kharif-1 season. The highest bulb yield (6.93t ha^{-1}) was weighted from the spacing 20cmx10 cm which was followed by 20x15 cm (4.96 t ha^{-1}) plant spacing which is statistically identical with the spacing of 30x10 cm (4.87 t ha^{-1}) and the lowest from the spacing 20x15 cm (4.3 t ha^{-1}).

Interaction effect of spacing and different cultivars

Significantly the highest bulb diameter (41.9 mm) was recorded from the variety Binapiaz-1 with 20x10cm followed by the variety Binapiaz-2 with spacing 30x10cm (40.4 mm). The lowest bulb diameter (75.2 mm) was obtained from the variety Binapiaz-2 with 30x10 cm. The increased in bulb diameter at wider plant spacing could be probably attributed to more nutrients, space, moisture availability and resulting in enlargement of their bulb size. Similarly, high plant density implies closer spacing and ultimate reduction in space available per plant, and then the tendency is real that bulb expansion might be limited due to smaller space for bulbing (Mohammed et. al., 2011).

Table 2: Determination of proper spacing of onion varieties in Kharif-1 season

Treatments	Plant height (cm)	Leaf $plant^{-1}$ (no.)	Bulb diameter (mm)	Neck diameter (mm)	Leaf fresh weight (g m^{-2})	Leaf dry weight (g m^{-2})	Bulb fresh weight (g m^{-2})	Bulb dry weight (g m^{-2})	Bulb yield (t ha^{-1})	Crop duration (days)
Variety										
Binapiaz-1 (V_1)	33.3	6.3	39.4	6.1	946	247	553	501.5	5.02	92
Binapiaz-2 (V_1)	33.1	6.4	38.9	5.9	905	236	498	454.5	4.55	92
Level of sig.	NS	NS	NS	NS	*	*	*	*	NS	-
Spacing										
20 cm×10 cm (S_1)	33.2	6.5	38.6	6.2	1416	354	775	693.3	6.93	
20 cm×15 cm (S_2)	33.6	6.5	40.1	6.3	954	238	545	496.3	4.96	
30 cm×10 cm (S_3)	33.3	6.2	39.4	6.0	942	258	529	486.7	4.87	
30 cm×20 cm (S_4)	33.1	6.6	38.9	5.7	470	117	254	235.7	2.36	
$LSD_{0.05}$	NS	0.5	2.2	0.8	189	60	70	63.7	0.64	
Variety× Spacing										
$V_1 S_1$	31.6	6.4	41.9	6.5	1433	358	825	735.0	6.95	
$V_1 S_2$	34.0	6.3	39.2	6.4	986	246	584	531.3	5.31	
$V_1 S_3$	34.0	6.5	38.3	6.0	921	275	546	501.0	5.01	
$V_1 S_4$	33.9	6.3	38.4	5.8	446	111	257	238.7	2.39	
$V_2 S_1$	34.7	6.6	38.0	5.9	1400	350	725	651.7	6.22	
$V_2 S_2$	33.2	6.6	38.2	6.1	922	230	505	461.3	4.61	
$V_2 S_3$	32.5	5.9	40.4	6.0	963	241	512	472.3	4.72	
$V_2 S_4$	32.2	6.9	39.3	5.6	494	123	251	232.7	2.33	
$LSD_{0.05}$	NS	0.8	3.1	1.1	268	85	99	90.1	0.90	
CV (%)	5.9	6.8	4.6	10.2	16	20	10	10.8	10.76	

* Significant at 5% level of probability; NS = Non significant

The maximum (1433 gm^{-2}) fresh weight of leaves was recorded from the variety Binapiaz-1 with spacing 30x10 cm followed by variety Binapiaz-2 with 30x10 cm. The minimum (494 gm^{-2}) fresh weight of leaves was obtained from the variety Binapiaz-2 with spacing 30x20 cm. The maximum fresh weight of bulb (825 gm^{-2}) was obtained from the variety Binapiaz-1 with spacing 20x10 cm followed by spacing 20x15 cm (584 gm^{-2}). The minimum bulb fresh weight was obtained from the variety Binapiaz-2 with 30x20 cm. Heavier bulbs in wider spacing might be attributed to the lower competition of plants for limited resources as compared to plants in narrower spacing which allowed higher assimilation and accumulate more dry matter in the bulbs. Gessesew et al., (2015) also reported that increase of mean fresh bulb weight from 41.97 to 92.2

g as an intra-row spacing increase from 10 to 15 cm. The maximum bulb yield (6.95t ha^{-1}) was recorded from the variety Binapiaz-1 with spacing 20x10cm followed by the Binapiaz-2 with spacing 20x10 cm (6.22t ha^{-1}). The minimum yield (2.33 t ha^{-1}) was recorded from the variety Binapiaz-2 with spacing 30x20 cm. This result is in agreement with findings of Nigullie and Biawas (2017) who found the highest total bulb yield from densely populated onion plants than sparsely planted ones.

CONCLUSION

This study was concentrated to the combined application of different spacing and varieties favorably influenced plant growth, yield attributes and total bulb yield. Results clearly emphasized that the importance of spacing as well as selection of varieties of onion, as the conjoint use of them yielded higher. The total yield of bulbs was increased with decreased in plant spacing. In general, variety Binapiaz-1 gave superior total bulb yield compared to others. The closest spacing (10x10 cm or 20x10 cm) was found to be better in giving total bulb yield than the wider spacing. The combined effect of plant spacing with different varieties showed significant variation in case of all parameters except plant height and number of leaves. In rabi season, highest yield (9.3 t ha^{-1}) was found in closer spacing i.e 10x10 cm in Binapiaz-1 followed by Binapiaz-2 (8.7 t ha^{-1}) while in kharif season, highest yield (6.95 t ha^{-1}) was found from Binapiaz-1 with 10x10 cm plant density. Economic analysis of such bulbs was not investigated in the study. Such study may be conducted in future to investigate the economic feasibility of preservation of such bulbs under normal storage conditions. These results however need to be further confirmed on multi locations large scale trials before passing as recommendations to the onion growers.

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