Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(3): 2511-2515
Received: 04-03-2018
Accepted: 05-04-2018

Ginoya AV
M. Sc. (Agri.) Student, College of Agriculture, JAU, Junagadh, Gujarat, India

Patel JB
Associate Professor, Department of Seed Science and Technology, College of Agriculture, JAU, Junagadh, Gujarat, India

Delvadiya IR
M. Sc. (Agri.) Student, College of Agriculture, JAU, Junagadh, Gujarat, India

Jethva AS
Assiatant Research Scientist, Vegetable Research Station, JAU, Junagadh, Gujarat, India

Correspondence
Ginoya AV
M. Sc. (Agri.) Student, College of Agriculture, JAU, Junagadh, Gujarat, India

Effect of bulb size and plant spacing on seed quality parameters of onion (*Allium cepa* L.) cv. GJWO 3

Ginoya AV, Patel JB, Delvadiya IR and Jethva AS

Abstract
The present investigation was conducted in the laboratory of Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh during 2016-17 with an aim to study the effect of bulb size [B_1 (25 $\pm$ 5 g, small size), B_2 (50 $\pm$ 5 g, medium size) and B_3 (75 $\pm$ 5 g, large size)] and plant spacing [S_1 (30 cm x 30 cm), S_2 (30 cm x 40 cm), S_3 (45 cm x 30 cm), S_4 (45 cm x 40 cm), S_5 (60 cm x 30 cm) and S_6 (60 cm x 40 cm)] on seed parameters of onion cv. Gujarat Junagadh White Onion 3 (GJWO 3). The characters *viz.*, germination percentage, root length (cm), shoot length (cm), root fresh weight (mg), shoot fresh weight (mg), root dry weight (mg), shoot dry weight (mg), vigour index - I (length) and vigour index - II (mass) were recorded from the seeds harvested from different combinations of treatments evaluated in field and analyzed as per the Completely Randomized Design (Factorial). The results showed that significantly the maximum germination percentage, root length, shoot length, root fresh weight, shoot fresh weight, root dry weight, shoot dry weight, vigour index I (length) and vigour index II (mass) were recorded in the seeds harvested from bulb size of 75 $\pm$ 5 g (B_3). The next best treatment with respect to all these traits was bulb size of 50 $\pm$ 5 g (B_2). Seeds harvested from the bulbs space planted at 60 cm x 40 cm (S_6) recorded significantly the highest germination percentage, root length, shoot length, root fresh weight, shoot fresh weight, root dry weight, shoot dry weight, vigour index I (length) and vigour index II (mass). The next best plant spacing with respect to all these seed parameters was bulbs planted at (S_5) 60 cm x 30 cm. The treatment combination B_3 x S_6 (bulb size 75 $\pm$ 5 g planted at the spacing of 60 cm x 40 cm) noted the maximum germination percentage, root length, shoot length, root fresh weight, shoot fresh weight, root dry weight, vigour index I (length) and vigour index II (mass).

Keywords: Bulb size, onion, spacing

Introduction
Onion is considered to be the second most important vegetable crop grown in the world after tomato. The name "Onia" is probably ranked to a city built by Onia in 1703 BC near the Gulf of Suez (Dawar *et al.*, 2007) [8]. The history of onion can be traced back to at least 5000 years. Onion is different from the other edible species of *Alliums* for its single bulb and is usually propagated by true botanical seed. It is popularly used both in immature and mature bulb stage as a vegetable and spices. Onion is liked for its flavour and pungency which is due to the presence of a volatile oil 'allylpropyl disulphide'- organic compound rich in sulphur. Onion contains several anti-cancerous agents which have shown to prevent cancer in animals. The beneficial compound called '*quercetin*' present in onion is a powerful antioxidant.
Onion is a biennial crop for the purpose of seed production. In one season, bulbs are produced from seed and in the second season, bulbs are replanted to produce seeds. Demand of onion seed is increasing due to increase in onion consumption. To sustain onion production, it is very difficult to increase yield horizontally, but there exists a great scope to do the same vertically that could be achieved by using good quality seed. Bulb size and plant spacing are considered important factors reflected in seed parameters of onion seed. Size of mother bulbs influenced the yield and quality of seeds (Abedin *et al.*, 1999) [2]. Asaduzzaman *et al.* (2012b) [3] reported that wider intra-row spacing had a significant effect on seed germination percentage. Therefore, the present study was conducted to investigate the effects of bulb size and plant spacing on different seed parameters of onion.

Materials and Methods
The present study was conducted in the laboratory of Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh during 2016-17. There were different three bulb size [B_1 (25 $\pm$ 5 g, small size), B_2 (50 $\pm$ 5 g, medium size)

and B_3 (75 ± 5 g, large size)] and six plant spacing [S_1 (30 cm x 30 cm), S_2 (30 cm x 40 cm), S_3 (45 cm x 30 cm), S_4 (45 cm x 40 cm), S_5 (60 cm x 30 cm) and S_6 (60 cm x 40 cm)] were evaluated in the field experiment following Randomized Block Design (Factorial) using cv. Gujarat Junagadh White Onion 3 (GJWO 3). The seed harvested from each of the treatment combinations were brought to the laboratory to study their effects on seed quality parameters *viz.*, germination percentage, root length (cm), shoot length (cm), root fresh weight (g), shoot fresh weight (g), root dry weight (mg), shoot dry weight (mg), Vigour Index I (length) and Vigour Index II (mass) and were analyzed by Completely Randomized Design (Factorial) in three repetitions. Analysis of variance for Completely Randomized Design (Factorial) was computed as per the method of Cochran and Cox (1957) [7]. Vigour index in terms of length and mass were determined as per formulae given by Abdul-Baki and Anderson (1973) [1].

Results and Discussion

The effect of bulb size and spacing on all seed quality parameters were found significant, but the interaction effect of bulb size and spacing were found non-significant for all seed quality parameters of onion after harvesting.

Germination percentage

Significantly the maximum germination in per cent (90.00%) was recorded in seeds harvested from bulb size 75 ± 5 g (B_3) over other bulb size, whereas significantly the minimum germination percentage (87.77%) was recorded in seeds harvested from 25 ± 5 g bulb (B_1) (Table 1). Seed harvested from bulb size 50 ± 5 g (B_2) was remained at par with both bulb size (B_1 and B_3) with germination of 88.22 per cent. Increase in germination percentage might be due to high food reserves present in the large bulb which, in turn, might supply nutrient to the seeds. The results are in accordance to the findings Asaduzzaman *et al.* (2012b) [3], Asaduzzaman *et al.* (2015) [5], Mollah *et al.* (2015) [14] and Debashis *et al.* (2016) [9]. The seeds harvested from plant spacing 60 cm x 30 cm (S_5) recorded significantly the highest germination percentage (90.11%) and it was remained at par with seeds harvested from plant spacing 60 cm x 40 cm (S_6) (89.78%), 45 cm x 40 cm (S_4) (89.44%), 45 cm x 30 cm (S_3) (89.00%) and 30 cm x 40 cm (S_2) (88.00%) (Table 1). This might be due to the fact that the wider spacing supplied more food materials to the growing seeds compared to the closest spacing resulted in to bold seeds and, in turn, high germination. These results concur with earlier reports of Asaduzzaman *et al.* (2012a) [4], Asaduzzaman *et al.* (2012b) [3], Elhag and Osman (2013) [11], Asaduzzaman *et al.* (2015) [5] and El-Damarany *et al.* (2015) [10] and Haile *et al.* (2017) [12]. The seeds harvested from treatment combination B_3 x S_6 followed by B_3 x S_5 and B_3 x S_4 noted higher germination percentage, while the minimum germination percentage was noted in seed harvested from B_1 x S_1 treatment combination (85.00%). The results are similar to the results reported earlier by Asaduzzaman *et al.* (2012b) [3], Asaduzzaman *et al.* (2015) [5] and Haile *et al.* (2017) [11] in onion.

Root length (cm)

The results indicated that seeds harvested from different bulb size planting exerted significant effect on root length. Significantly the maximum root length was recorded in the seeds harvested from bulb size 75 ± 5 g (2.13 cm) (B_3), whereas significantly the minimum root length was recorded in seeds harvested from bulb size 25 ± 5 g (B_1) (1.75 cm) (Table 1). High food reserves present in the large bulb might supply nutrient properly to the seeds, which perhaps cause highest weight of 1000 seed and, in turn, high germination and longer root length. The results are in accordance with the findings of Badawi *et al.* (2010) [6] reported for root length in onion. The seeds harvested from plant spacing 60 cm x 40 cm (S_6) recorded significantly the maximum root length (2.14 cm), whereas significantly the minimum root length (1.63 cm) was reported in seeds harvested from plant spaced at 30 cm x 30 cm (S_1). This might be due to the fact that the wider spacing supplied more food materials to the growing seeds compared to the closest spacing resulted in to bold seeds and, in turn, longer root length. The results are in accordance with the findings of Teshome *et al.* (2015) [15] reported for root length in onion. However, relatively the higher root length was produced by the seeds harvested from treatment combination B_3 x S_6, followed by B_3 x S_5 and B_3 x S_4, while it was noted the minimum in treatment combination B_1 x S_1 followed by B_2 x S_1 and B_1 x S_2.

Table 1: Effect of bulb size and spacing on germination percentage, root length (cm), shoot length (cm) and root fresh weight (mg) in onion

Treatment	Germination percentage	Root length (cm)	Shoot length (cm)	Root fresh weight (mg)
Bulb size				
B_1 = 25 ± 5 g	87.77	1.75	4.96	7.21
B_2 = 50± 5 g	88.22	1.84	5.19	7.51
B_3 = 75 ± 5 g	90.00	2.13	5.51	7.82
S. Em. ±	0.64	0.02	0.05	0.07
C.D. at 5%	1.83	0.05	0.14	0.21
Spacing				
S_1 = 30 cm x 30 cm	85.67	1.63	4.95	7.11
S_2 = 30 cm x 40 cm	88.00	1.73	5.04	7.25
S_3 = 45 cm x 30 cm	89.00	1.91	5.15	7.43
S_4 = 45 cm x 40 cm	89.44	2.00	5.27	7.59
S_5 = 60 cm x 30 cm	90.11	2.05	5.39	7.73
S_6 = 60 cm x 40 cm	89.78	2.14	5.53	7.98
S. Em.±	0.90	0.03	0.07	0.10
C.D. at 5%	2.28	0.08	0.20	0.30
Bulb size x spacing				
B_1 x S_1	85.00	1.55	4.76	6.73
B_1 x S_2	87.33	1.59	4.82	6.85
B_1 x S_3	88.33	1.78	4.91	7.14
B_1 x S_4	88.67	1.81	4.99	7.32
B_1 x S_5	89.00	1.83	5.10	7.50
B_1 x S_6	88.33	1.96	5.23	7.73
B_2 x S_1	85.67	1.57	4.93	7.19
B_2 x S_2	88.00	1.62	5.01	7.28
B_2 x S_3	88.33	1.80	5.12	7.39
B_2 x S_4	89.00	1.91	5.25	7.58
B_2 x S_5	89.33	2.00	5.32	7.66
B_2 x S_6	89.00	2.11	5.52	7.98
B_3 x S_1	86.33	1.78	5.17	7.42
B_3 x S_2	88.67	1.96	5.30	7.64
B_3 x S_3	90.33	2.13	5.42	7.75
B_3 x S_4	90.67	2.27	5.57	7.88
B_3 x S_5	92.00	2.32	5.75	8.02
B_3 x S_6	92.00	2.35	5.85	8.22
Mean	88.67	1.91	5.22	7.52
S. Em.±	1.56	0.05	0.12	0.18
C.D. at 5%	NS	NS	NS	NS
C.V. %	3.05	4.40	4.09	4.18

Shoot length (cm)

Significantly the maximum shoot length (5.51 cm) was recorded in the seeds harvested from bulb size 75 ± 5 g (B_3), whereas significantly the minimum shoot length (4.96 cm) was recorded in seeds harvested from bulb size 25 ± 5 g (B_1) (Table 1). The results are in accordance with the findings of Badawi *et al.* (2010) [6] reported for shoot length in onion.

The seeds harvested from plant spacing 60 cm x 40 cm (S_6) recorded significantly the maximum shoot length (5.53 cm) and it was at par with 60 cm x 30 cm (S_5) (5.39 cm), while significantly the minimum shoot length (4.95 cm) was reported in seeds harvested from plant spaced at 30 cm x 30 cm (S_1) and it was at par with 30 cm x 40 cm (S_2) (5.04 cm) and 45 cm x 30 cm (S_3) (5.15 cm). This might be due to the fact that the wider spacing supplied more food materials to the growing seeds compared to the closest spacing resulted in to bold seeds and, in turn, longer shoot length. The results are in accordance with the findings of Teshome *et al.* (2015) [15] reported for shoot length in onion. However, relatively the maximum shoot length was produced by the seeds harvested from treatment combination B_3 x S_6, (5.85 cm) followed by B_3 x S_5 and B_3 x S_4, while it was noted the minimum in treatment combination B_1 x S_1 (4.76 cm) followed by B_1 x S_2 and B_1 x S_3.

Root fresh weight (mg)

Significantly the maximum root fresh weight was recorded in the seeds harvested from bulb size 75 ± 5 g (7.82 mg) (B_3), whereas significantly the minimum root fresh weight was recorded in seeds harvested from bulb size 25 ± 5 g (B_1) (7.21 mg) (Table 1). The seeds harvested from plant spaced at 60 cm x 40 cm (S_6) recorded significantly the maximum root fresh weight (7.98 mg) and it was at par with 60 cm x 30 cm (S_5) (7.73 mg), while significantly the minimum root fresh weight (7.11 mg) was reported in seeds harvested from plant spaced at 30 cm x 30 cm (S_1) and it was at par with 30 cm x 40 cm (S_2) (7.25 mg). This might be due to the fact that the wider spacing supplied more food materials to the growing seeds compared to the closest spacing resulted in to bold seeds and, in turn, longer root length and ultimately higher root fresh weight. However, relatively the maximum root fresh weight was produced by the seeds harvested from treatment combination B_3 x S_6, (8.22 mg) followed by B_3 x S_5 and B_2 x S_6, while it was noted the minimum in treatment combination B_1 x S_1 (6.73 mg) followed by B_1 x S_2 and B_1 x S_3.

Shoot fresh weight (mg)

Significantly the maximum shoot fresh weight (22.55 mg) was recorded in the seeds harvested from bulb size 75 ± 5 g (B_3), whereas significantly the minimum shoot fresh weight (21.72 mg) was recorded in seeds harvested from bulb size 25 ± 5 g (B_1) (Table 2). The seeds harvested from plant spaced at 60 cm x 40 cm (S_6) recorded significantly the maximum shoot fresh weight (22.57 mg) and it was at par with 60 cm x 30 cm (S_5) (22.36 mg) and 45 cm x 40 cm (S_4) (22.19 mg). This might be due to the fact that the wider spacing supplied more food materials to the growing seeds compared to the closest spacing resulted in to bold seeds and, in turn, longer shoot length and ultimately higher shoot fresh weight. However, comparatively the maximum shoot fresh weight was produced by the seeds harvested from treatment combination B_3 x S_6, (23.08 mg) followed by B_3 x S_5 and B_3 x S_4, while it was noted the minimum in treatment combination B_1 x S_1 (21.45 mg) followed by B_1 x S_2 and B_1 x S_3.

Root dry weight (mg)

Significantly the maximum root dry weight (0.35 mg) was recorded in the seeds harvested from bulb size 75 ± 5 g (B_3), whereas significantly the minimum root length (0.32 mg) was recorded in seeds harvested from bulb size 25 ± 5 g (B_1) and it was at par with the seeds harvested from bulb size 50 ± 5 g (B_2) (0.33 mg) (Table 2). The results are in accordance with the findings of Badawi *et al.* (2010) [6] reported for root dry weight in onion. The seeds harvested from plant spaced at 60 cm x 40 cm (S_6) recorded significantly the maximum root dry weight (0.35 mg) and it was at par with 60 cm x 30 cm (S_5), 45 cm x 40 cm (S_4) and 45 cm x 30 cm (S_3) with root dry weight of 0.34, 0.34 and 0.33 mg, respectively. Similarly, significantly the minimum root dry weight (0.32 mg) was reported in seeds harvested from plant spaced at 30 cm x 30 cm (S_1) and 30 cm x 40 cm (S_2) and it was at par with 45 cm x 40 cm (S_4) and 45 cm x 30 cm (S_3) with root dry weight of 0.34 and 0.33 mg, respectively. This might be due to the fact that wider spacing supplied more food materials to the growing seeds compared to the closest spacing resulted in to bold seeds and, in turn, longer root length and higher root dry weight. The results are in accordance with the findings of Teshome *et al.* (2015) [15] reported for root dry weight in onion. However, relatively the higher root dry weight (0.36 mg) was produced by the seeds harvested from treatment combination B_3 x S_6 and B_3 x S_5, while it was noted the minimum (0.30 mg) in treatment combination B_1 x S_1 and B_1 x S_2.

Table 2: Effect of bulb size and spacing on shoot fresh weight (mg), root dry weight (mg), shoot dry weight (mg), Vigour Index – 1 (length) and Vigour Index - II (mass) in onion

Treatment	Shoot fresh weight (mg)	Root dry weight (mg)	Shoot dry weight (mg)	Vigour index - I (length)	Vigour index - II (mass)
Bulb size					
B_1 = 25 ± 5 g	21.72	0.32	0.96	590.14	112.51
B_2 = 50± 5 g	22.04	0.33	0.98	620.39	115.54
B_3 = 75 ± 5 g	22.55	0.35	1.00	689.10	121.18
S. Em. ±	0.13	0.003	0.01	6.97	1.34
C.D. at 5%	0.36	0.01	0.02	19.99	3.84
Spacing					
S_1 = 30 cm x 30 cm	21.70	0.32	0.96	564.27	109.37
S_2 = 30 cm x 40 cm	21.82	0.32	0.97	595.76	113.37
S_3 = 45 cm x 30 cm	22.00	0.33	0.97	628.29	116.08
S_4 = 45 cm x 40 cm	22.19	0.34	0.98	650.52	117.96
S_5 = 60 cm x 30 cm	22.36	0.34	0.99	671.18	120.15
S_6 = 60 cm x 40 cm	22.57	0.35	1.00	689.24	121.54
S. Em.±	0.18	0.01	0.01	9.86	1.90
C.D. at 5%	0.52	0.02	0.03	28.27	5.44
Bulb size x spacing					
B_1 x S_1	21.45	0.30	0.95	535.94	106.08

B_1 x S_2	21.52	0.30	0.95	559.78	109.76
B_1 x S_3	21.63	0.32	0.96	590.87	112.58
B_1 x S_4	21.72	0.32	0.96	602.94	113.88
B_1 x S_5	21.90	0.33	0.97	616.53	115.91
B_1 x S_6	22.11	0.34	0.98	634.78	116.88
B_2 x S_1	21.68	0.32	0.96	556.72	109.64
B_2 x S_2	21.75	0.32	0.96	583.73	113.21
B_2 x S_3	21.92	0.33	0.97	611.57	114.69
B_2 x S_4	22.13	0.34	0.98	637.65	117.07
B_2 x S_5	22.24	0.34	0.99	654.13	118.37
B_2 x S_6	22.51	0.35	1.00	678.56	120.22
B_3 x S_1	21.96	0.33	0.97	600.14	112.40
B_3 x S_2	22.18	0.34	0.98	643.77	117.13
B_3 x S_3	22.46	0.34	1.00	682.43	120.97
B_3 x S_4	22.72	0.35	1.01	710.99	122.94
B_3 x S_5	22.93	0.36	1.02	742.88	126.17
B_3 x S_6	23.08	0.36	1.02	754.38	127.51
Mean	22.11	0.33	0.98	633.21	116.41
S. Em.±	0.31	0.01	0.02	17.07	3.28
C.D. at 5%	NS	NS	NS	NS	NS
C.V. %	2.45	4.52	2.87	4.67	4.89

Shoot dry weight (mg)

Significantly the maximum shoot dry weight (1.00 mg) was recorded in the seeds harvested from bulb size 75 $\pm$ 5 g (B_3), whereas significantly the minimum root length (0.32 mg) was recorded in seeds harvested from bulb size 25 $\pm$ 5 g (B_1) and it was at par with the seeds harvested from bulb size 50 $\pm$ 5 g (B_2) (0.33 mg) (Table 2). High food reserves present in the large bulb might supply nutrient properly to the seeds, which perhaps cause the highest weight of 1000 seed and, in turn, longer shoot length and ultimately high shoot dry weight. An examination of data (Table 2) showed that seeds harvested from different plant spacing exerted significant effect on shoot dry weight. The seeds harvested from plant spaced at 60 cm x 40 cm (S_6) recorded significantly the maximum shoot dry weight (1.00 mg) and it was at par with 60 cm x 30 cm (S_5), 45 cm x 40 cm (S_4) and 45 cm x 30 cm (S_3) with shoot dry weight of 0.99, 0.98 and 0.97 mg, respectively. The results are in accordance with the findings of Teshome *et al.* (2015) [15] reported for shoot dry weight in onion. However, relatively the higher shoot dry weight (1.02 mg) was produced by the seeds harvested from treatment combination B_3 x S_6 and B_3 x S5, while it was noted the minimum (0.95 mg) in treatment combination B_1 x S_1 and B_1 x S_2.

Vigour index -I (length)

Significantly the maximum vigour index – I (length) (689.10) was recorded in the seeds harvested from bulb size 75 $\pm$ 5 g (B_3), whereas significantly the minimum vigour index – I (length) (590.14) was recorded in seeds harvested from bulb size 25 $\pm$ 5 g (B_1) (Table 2). The results are in accordance with the findings of Shaikh *et al*. (2002) reported for vigour index in onion. The seeds harvested from plant spaced at 60 cm x 40 cm (S_6) recorded significantly the maximum vigour index – 1 (length) (689.24) and it was at par with 60 cm x 30 cm (S_5) (671.18). Significantly the minimum vigour index – I (length) (564.27) was reported in seeds harvested from plant spaced at 30 cm x 30 cm (S_1) (Table 4). The results are in accordance with the findings of Kumar *et al.* (2015) [13] and Teshome *et al.* (2015) [15] reported for vigour index – I (length) in onion. However, relatively the higher vigour index – I (length) (754.38) was produced by the seeds harvested from treatment combination B_3 x S_6, while it was noted the minimum (535.94) in by treatment combination B_1 x S_1.

Vigour index - II (mass)

Significantly the maximum vigour index – II (mass) (121.18) was recorded in the seeds harvested from bulb size 75 $\pm$ 5 g (B_3), whereas significantly the minimum vigour index – II (mass) (112.51) was recorded in seeds harvested from bulb size B_1 (Table 2). The results are in accordance with the findings of Shaikh *et al*. (2002) reported for vigour index in onion. The seeds harvested from plant spaced at 60 cm x 40 cm (S_6) recorded significantly the maximum vigour index – II (mass) (121.54) and it was at par with 60 cm x 30 cm (S_5) (120.15) and 45 cm x 40 cm (S_4) (117.96) (Table 4). Significantly the minimum vigour index – II (mass) (109.37) was reported in seeds harvested from plant spaced at 30 cm x 30 cm (S_1) and it was at par with 30 cm x 40 cm (S_2) (113.37). The results are in accordance with the findings of Kumar *et al.* (2015) [13] and Teshome *et al.* (2015) [15] reported for vigour index – II (mass) in onion. However, relatively the higher vigour index – II (mass) (127.51) was produced by the seeds harvested from treatment combination B_3 x S_6, while it was noted the minimum (106.08) in treatment combination B_1 x S_1.

Conclusion

The final conclusion that can be reached from the present study that the bulb size 75 $\pm$ 5 g (B_3) irrespective of plant spacing noted significantly the highest values for different seed quality parameters after the harvest of seeds of onion. Similarly, irrespective of bulb size, bulbs planted at the spacing of 60 cm x 40 cm (S_6) also produced significantly the highest values for seed quality parameters after the harvest of seeds of onion. Among the different combinations of bulb size and plant spacing, bulb size 75 $\pm$ 5 g planted at the spacing of 60 cm x 40 cm (B_3 x S_6) was found a best suited, as it having highest different seed quality parameters after the harvest of seeds of onion. Therefore, looking to the different seed parameters of onion seed after harvesting, it is suggested that for getting the higher onion seed yield of good quality, large size onion bulbs of Gujarat Junagadh White Onion 3 (GJWO 3) could be planted at the spacing of 45 cm x 30-40 cm.

References

1. Abdul-Baki A, Anderson JD. Vigor determination in soybean seed by multiple criteria. Crop Sci. 1973; 13(6):630-633.

2. Abedin MJ, Rahim MA, Islam KS, Haider MA. Effect of planting date and bulb size on the yield and quality of onion seed. Bangladesh J Seed Sci. Tech, 1999; 3(1, 2):25-28.
3. Asaduzzaman M, Hasan MM, Hasan MM, Moniruzzaman M. Quality seed production of onion (*Allium cepa* L.): An integrated approach of bulb size and plant spacing. J Agric. Res. 2012b; 50**(**1):119-128.
4. Asaduzzaman M, Hasan MM, Hasan MM, Moniruzzaman M, Howlader MHK. Effect of bulb size and spacing on seed production of onion (*Allium cepa* L.). Bangladesh J Agril. Res, 2012a**;** 37(3):405-414.
5. Asaduzzaman M, Robbani M, Ali M, Hasan MM, Begum M, Hasan MM *et al*. Mother bulb weight and plant density influence on seed yield and yield attributes of onion. Int. J Veg. Sci, 2015; 21(1):98-108.
6. Badawi MA, Seadh SE, EL-Emery MI, Shalaby AEM. Onion seed yield and its quality as influenced by storage methods, mother bulb size and harvesting time. J Plant Prod. 2010; 1(2):239-249.
7. Cochran WG, Cox GM. Experimental Designs. 2nd Edition, John Wiley and Sons, New York, 1957, 615.
8. Dawar NM, Wazir FK, Dawar M, Dawar SH. Effect of planting density on growth and yield of onion varieties under climatic conditions of Peshawar. Sarhad J Agric. 2007; 23(4):911-917.
9. Debashis M, Santra P, Maity TK, Basu AK. Quality seed production of onion (*Allium cepa* L.) cv. Sukhsagar as influenced by bulb size and date of planting. Agri. Res. Tech. 2016; 2(3):1-6.
10. El-Damarany AM, El-Shaikh KAA, Obiadalla-Ali HA, Abdel-Kader MM. Effect of mother bulb size and planting space on seed production of onion (*Allium cepa* L.) cultivar Giza 6 Mohassan. J Agril. Vet. Sci. 2015; **8**(2):187-200.
11. Elhag AZ, Osman HM. Effect of plant spacing on onion (*Allium cepa* L.) seed quality. Universal J Appl. Sci, 2013; 1(2):52-55.
12. Haile A, Tesfaye B, Worku W. Seed yield of onion (*Allium cepa* L.) as affected by bulb size and intra-row spacing. African J Agric. Res. 2017; 12(12):987-996.
13. Kumar S, Tomar BS, Jain SK, Singh N, Prasad R, Munshi AD. Effect of planting time and density on plant growth, seed yield and quality attributes in onion (*Allium cepa*) cv. Pusa Riddhi. Indian J Agril. Sci, 2015; 85(12):1578–1585.
14. Mollah MRA, Ali MA, Ahmad M, Hassan MK, Alam MJ. Effect of bulb size on the yield and quality of true seeds of onion. European J Biotech Biosci, 2015; 3(7):23-27.
15. Teshome H, Woldeselassie A, Simon T. Seed yield and quality of onion (*Allium cepa* var. Cepa) seed as influence by bulb treatment and spacing patterns at Larena, Southern Ethiopia. J Nat. Sci. Res, 2015; 5(9):82-86.