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Effect of bulb size on the yield and quality of true seeds of onion

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Abstract
The present study was stimulated by the problem of onion seed production where seed production is possibly only winter period after which rapid increase in temperature as well as early shower adversely affect the quality of seed. The experiment was laid out in a randomized complete block design with four replications to determine the effect of bulb size on the yield and quality of onion seeds. Three treatments viz. B_1= 10 g, B_2= 15 g and B_3= 20 g were consisted to achieve the objective. The research work was done at On-Farm Research Division, BARI, Bogra during September, 2011 to June, 2012. The results revealed that the growth parameters, seed yield parameters, health and quality of harvested seeds were significantly influenced by the different treatments. Results showed that among different treatments, optimum bulb size is 15 g for production true seeds of onion at Bogra region in Bangladesh.

Keywords: Bulb size, yield, quality, true seeds, onion.

1. Introduction
Onion (*Allium cepa* L.) is one of the most important spice crops in Bangladesh. It was introduced into the Asian sub-continent from Palestine (MacGillivary, 1961) [10]. Onion has great economic importance due to its medicinal and dietetic values. It is widely used as condiment, salad and dressing of food. The average consumption of onion in Bangladesh is 25 g/head/day (BBS, 2010) [4]. It is grown in almost all the districts of Bangladesh; its commercial cultivation is concentrated in Faridpur, Dhaka, Rajshahi, Comilla, Mymensingh, Jessore, Rangpur and Pabna (BBS, 2010) [4]. Onion is grown in about 1, 87000 ha of land. The annual production is 17, 01000 tons of onion bulbs (BBS, 2012) [5].
Onion is a biennial crop. It completes vegetative phase with bulb production in the first year. These bulbs are used as planting material for production of true seed in the second year. The demands of quality true seeds are increasing day by day. The price of true seeds is also high. The seeds available in the market are poor in quality. The total production of onion seed in Bangladesh is about 150 tons/year but the requirement is more than 900 tons (BBS, 2010) [4]. Climatic condition of Bangladesh is not suitable for the production of true seed by seeds to seed method (Rahim, 1991) [14]. Onion is a thermo and photosensitive crop (Brewster, 1994) [6]. The rate of inflorescence initiation was strongly influenced by the size of the mother bulbs. Size of mother bulbs influenced the yield and quality of seeds (Abedin *et al*., 1999) [1]. Large size bulbs produced higher yield compared to smaller one but large bulb may not be always economic in respect of return (Rahim, 1991) [14]. Continuous use on small sized bulbs may reduce the seed quality of onion (Brewster, 1994) [6]. Significant influences of bulb size on the number of umbels and seed yield of onion (Mollah *et al*., 1987) [11]. Keeping all these above facts in view, the present study was undertaken to determine the effect of bulb size for maximizing quality true seeds of onion.

2. Materials and methods
The experiment was carried out at On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI), Bogra during the period of September, 2011 to June 2012.

2.1. Soil and climate: The experimental area is situated at the western part of Bogra district under Level Barind Tract of Agroecological Zone 25 (AEZ-25). Geographically the experimental field is located at 24.6° N latitude and 89.3ºE longitude at an average elevation of 20 m above the sea level. The soil is clay loam in texture. The pH value was 5.65. Monsoon started in the month of May and ceased after September. Rest of the months had received feeble rainfall.

2.2. Land preparation: The experimental field was opened with a power tiller at the month of September, 2011. The land was thoroughly prepared by ploughing and cross ploughing followed by laddering. The subsequent operations were done with harrow, spade, hammer etc. The weeds and stubbles were collected and removed from the field. The surface was leveled with a harrower (ladder) driven by a power tiller. Irrigation and drainage channels were made around the plots. The corners of the plots were trimmed by the spade. The lay-out of the experiment was prepared according to the design of experiment.

2.3. Design of experiment: The field experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. The field was divided into four blocks after final land preparation. Each block was divided into four experimental units. The treatments were assigned in each block at random. The size of each unit plot was 1m × 3m. Block to block and plot to plot distance were 100 cm and 50 cm, respectively.

2.4. Plant spacing: Row to row and bulb to bulb were 25 cm and 20 cm, respectively. Each plot had four rows. Fifteen seed bulbs were sown in each row.

2.5. Treatments: Bulb size was employed at three temperatures viz. B_1= 10 g, B_2= 15 gand B_3= 20 g was considered as treatment.

2.6. Variety: BARI Piaj-1 was used in the research program. It was released by Spices Research Centre (SRC) of Bangladesh Agricultural Research Institute (BARI), Bogra, Bangladesh.

2.7. Selection of bulb: Different size of bulbs such as 10, 15 and 20 g were preliminarily sorted out by eye estimation. The bulbs of the distinct three groups were separated by taking weight with the help of an electric balance. The bulbs were tagged and kept separately in different white cotton cloth bag.

2.8. Application of fertilizer and manure: The crop was fertilized with recommended doses of fertilizers and manure at the rate of 250, 275, 150, 110, 3 and 5 kg/ha Urea, Triple superphosphate (TSP), Muriate of potash (MoP), Gypsum, Zinc oxide and Boric acid, respectively (Anonymous, 2010) [2]. In addition, cowdung was applied at the rate of 10 t/ha. The entire amount of TSP, Gypsum, Zinc oxide, Boron, one third of Urea and one third of MoP were applied at the time of final land preparation. Rest of the Urea and MoP were applied in three equal installments at 30, 50 and 70 days after planting (DAP).

2.9. Irrigation and drainage: Water was sprinkled with a watering can after emergences of the shoots at 10 DAP. Afterword each plot was irrigated at 30, 50, 70 and 105 DAP to keep the field soil nearly at field capacity. Excess water was drained out properly as and when necessary.

2.10. Intercultural operations: First weeding was done by hand picking just after 15 days of shoot emergence. The second weeding was done by "Khurpi" (hand weeder) at 35 DAP. Rovral (50 WP) @ 2g/l of water were sprayed at 15 days interval starting from 30 DAP upto 120 DAP to control purple blotch. Admire were applied @ 0.5 ml/l of water at 105 and 120 DAP to control thrips.

2.11. Staking: Staking of each shoot was made by plastic strips and bamboo sticks. The bamboo sticks were placed in around the plots. About 4-5 cm of each stick was inserted into the soil. The plastic strips were tied between the sticks along the rows of the shoots.

3. Data collection: Data on different growth parameters and yield parameters were collected at different growth stages of the plants.

3.1. Emergence (%) per plot: The numbers of seed bulbs were counted after emergence of shoot above the ground level during 7-15 DAP. Percent emergence in each plot was calculated by the following formula:

$$\text{Emergence (\%)} = \frac{\text{Number of seed bulbs emerged}}{\text{Total number of seed bulbs planted}} \times 100$$

3.2. Plant height: twenty plants were randomly selected at 60 DAP in each plot. The height was measured from the ground level to the tip of the longest leaf. The average plant height was expressed in centimeter (cm).

3.3. Number of leaves per plant: twenty plants were selected at random in each plot. The number of leaves of the 20 selected plants was counted at 60 DAP.

3.4. Leaf area index (LAI): Leaf area index is the ratio of leaf area to the ground area. An area of one square meter was selected at the centre of each plot. The plants were uprooted at 60 DAP. The leaves were separated from the pseudo-stem and washed in running tap water. Free water from the surface of each leaf was dried by soaking with tissue paper. Individual leaf was splited longitudinally into two halves by a sharp knife. Leaf area was measured by an automatic leaf area meter (LI 3000, USA). Each half of the leaf was placed into the leaf area meter. Total area of all leaves of one square meter in each plot was then calculated. Leaf area index was determined by the following formula:

$$\text{Leaf area index} = \frac{\text{Total leaf area}}{\text{Total ground area}} = \frac{\text{Total leaf area sq m}}{1\,\text{sq m}}$$

3.5. Length and diameter of the pseudo-stem: Twenty pseudo-stems were selected at random. The length was measured from ground level to the point of leaf initiation at 60 DAP. Diameter of the pseudo-stem was measured just above the ground level at 60 DAP. The data were expressed in centimeter (cm).

3.6. Number of stalks per plant: Twenty plants were selected at random from each plot. The number of stalks of the plants were counted in each plot at 90 DAP.

3.7. Number of umbel per plant: Twenty plants were selected at random. The number of umbels of the selected plants was recorded after completion of flowering in each plot. The average of 20 plants was computed.

3.8. Umbel diameter: The diameter at the middle of the umbel was measured from 20 umbels of 20 randomly selected plants at maximum flowering stage in each plot and expressed in centimeter (cm).

3.9. Number of flowers per umbel: The numbers of flowers in each umbel was counted from randomly selected 20 umbels at maximum flowering stage in each plot.

3.10. Harvesting and processing: The duration of crop is 145 to 150 days. When the seeds inside the capsules become black and 25-30% black seeds were exposed on the umbel, then each umbel was cut with 5-7 cm flower stalk. Harvesting was continued for 3-7 days. The umbels were sun dried. Threshing was done by light beating and hand rubbing of the umbels. The seeds were cleaned and sun dried for 3-4 days until seed moisture reduced to below 8%. The seeds of individual plots were processed separately and contained in a separate brown paper bag and preserved for further use.

3.11. Number of seeds per umbel: It was counted from randomly selected 10 umbels of selected plants at maximum fruit set stage.

3.12. Weight of 1000-seeds: One thousand seeds were selected at random from each plot. The 1000-seed weight was recorded on an electric balance and expressed in gram (g).

3.13. Seed weight per plant: Twenty plants were selected at random from each plot and the seeds were harvested. Seed weight were recorded on an electric balance and expressed in gram (g).

3.14. Seed weight per plot: Total amount of seeds of each plot were bulked and weight in gram (g) was recorded.

3.15. Seed moisture content (%): The moisture content of seeds was determined by universal type moisture meter (Oriental Apparatus Workshop, India). Two hundred gram of seed was used for each test. The moisture meter measures electrical conductivity through a predetermined thickness of measured seed and the reading was converted to a moisture percentage through a calibrated dial. To add confidence to the result, the machine was cross checked periodically obtaining results from an ISTA prescribed oven method. Tests were replicated according to the requirement for each sample.

3.16. Seed germination: Germination test was carried out in a plastic tray at On Farm Research Division, BARI, Seujgari, Bogra according to the International Rules for Seed Testing (ISTA, 1996) [8]. Sand was used as substrate for germination test. The plastic tray was filled with moist sand. Adequate moisture was maintained in the substrate. Four hundred pure seeds were taken at random from each treatment. One hundred seeds were placed in each tray and were considered as a replication. There were four replications for each treatment. Number of normal seedlings, abnormal seedlings, dead seeds and ungerminated seeds were counted. The first counting was done on the 6th and the second counting on the 12th day after placing the seeds on the substrate. Germination percentage was determined by the following formula.

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Number of seeds tested}} \times 100$$

3.17. Seed borne infection: Seed samples from each treatment were subjected to seed health test by Blotter incubation method following the procedure of International Rules for Seed Testing (ISTA, 1996) [8]. Three pieces of 9 cm diameter filter papers (Whatman No. 1) were soaked in distilled water and placed at the bottom of a plastic Petri dish. Four hundred seeds were taken at random from each treatment. Twenty five seeds (25) were placed on filter paper in each petri dish. Sixteen petri-dishes were used for each treatment. The petri-dishes were incubated for 7 days. Seed borne infection was recorded. Temporary slides were prepared and examined under the compound electric microscope and identified with the help of appropriate keys. The numbers of infected seeds with fungal pathogen were recorded. The results were expressed in percentage as follows:

$$\text{Seed borne infection (\%)} = \frac{\text{Number of infected seeds}}{\text{Number of seeds tested}} \times 100$$

4. Analysis of data: The data collected on various parameters related to the experiments were subjected to statistical analysis according to the design of experiment by MSTAT computer package program. Differences among the treatment means were compared following Duncan's Multiple Range Test (DMRT).

5. Results and Discussion

The effect of bulb size on the different growth parameters are presented in Table 1. The emergence of bulbs was 97.60% in B_3 and 97.08% in B_2. The lowest emergence of bulb 93.23% was recorded B_1. The plant height was 49.67 cm in B_3 and 44.16 cm in B_1. The number of leaves/plant was 19.49 in B_3 and 18.67 in B_2. The lowest number of leaves (12.85)/plant produced in B_1. The leaf area index was 4.78 in B_3. The lowest leaf area index (3.15) was found in B_1. The highest length of pseudo-stem (8.95 cm) was recorded in B_3 and the lowest (7.57 cm) in B_1. Diameter of the pseudo-stem was 4.65 cm in B_3 and 4.46 cm in B_2. The lowest diameter (3.40 cm) was found in B_1.

Table 1: Effect of bulb size on the growth parameters of BARI Piaj-1

Treatment (Bulb size)	Bulb emergence/plot		Plant height (cm)	No. of leaves/ plant	Leaf area index	Pseudo-stem	
	Number	(%)				Length (cm)	Diameter (cm)
B_1=10 g	55.94 b	93.23 b	44.16 c	12.85 b	3.15 b	7.57c	3.40 b
B_2=15 g	58.25 a	97.08 a	47.63 b	18.67 a	4.58 a	8.57 b	4.46 a
B_3=20 g	58.56 a	97.60 a	49.67 a	19.49 a	4.78 a	8.95 a	4.65 a
LSD $_{(0.05)}$	1.58	2.63	1.94	1.53	0.44	0.27	0.30
CV (%)	6.80	11.33	5.72	12.49	14.79	6.53	10.00

Means followed by the same letter in a column did not differ significantly at the 5% level by DMRT.

The number of stalk/plant was 4.72 in B_3 and it was identical with B_2. The lowest number of stalk/plant was 3.45 recorded in B_1 (Table 2). Similarly, the number of umbel/plant was identical in B_3 (4.65) and B_2 (4.57). The lowest number of umbel/plant (3.45) was recorded in B_1. The umbel diameter was 7.77 cm in B_3 and 7.64 cm in B_2. The umbel diameter was 5.09 cm present in B_1. The number of flowers/umbel was identical in B_3 and B_2. The lowest number of flowers/umbel was 351.44 in B_1. The number of seeds/umbel was 287.73 in B_3 and 284.18 in B_2. The lowest number of seeds/umbel (192.54) was harvested from B_1. The 1000-seed-weight was 4.01g in B_3 and 3.95 g in B_2. The lower 1000-seed weight was 2.68 g in B_1. The seed weight/plant was 5.17 g in B_3. It was 5.09 g in B_2. The lowest seed weight/plant was recorded in B_1. The seed weight/plot was 295.69 g in B_3. It was followed by 291.55 g in B_2. The lower seed weight/plot was 197.55 g in B_1 (Table 2).

Table 2: Effect of bulb size on the seed yield parameters of BARI Piaj-1

Treatment (Bulb size)	No. of stalk/ plant	No. of umbel/ plant	Umbel diameter (cm)	No. of flowers/ umbel	No. of seeds/ umbel	1000-seed weight (g)	Seed weight/plant (g)	Seed weight/ plot (g)
B_1=10 g	3.45 b	3.45 b	5.09 b	351.44 b	192.54 b	2.68 b	3.45 b	197.55 b
B_2=15 g	4.61 a	4.57 a	7.64 a	518.74 a	284.18 a	3.95 a	5.09 a	291.55 a
B_3=20 g	4.72 a	4.65 a	7.77 a	524.69 a	287.73 a	4.01 a	5.17 a	295.69 a
LSD $_{(0.05)}$	0.25	0.32	0.24	13.68	4.60	0.07	0.18	4.86
CV (%)	8.15	10.63	6.62	6.04	5.87	6.09	6.25	6.92

Means followed by the same letter in a column did not differ significantly at the 5% level by DMRT

The main effect of bulb size on seed health and quality of onion seeds are presented in Table 3. The moisture content of the seeds did not differ significantly among the treatments, but there was significant difference in seed germination. Maximum germination (78%) was recorded in B_2. It was 77% in B_3. The lowest germination was found in B_1. The incidence of seed borne pathogen differed significantly among the treatments. The lower fungal pathogen (3.31%) (*Alternaria porri*) was recorded in B_2 and 3.50% in B_3. The highest seed borne pathogen was recorded in B_1.

Table 3: Effect of bulb size on health and quality of true seeds of BARI Piaj-1

Treatment (Bulb size)	Moisture (%)	Germination (%)	Seed borne fungi (%)
B_1=10 g	7.56	62 b	6.81 a
B_2=15 g	7.56	78 a	3.31 b
B_3=20 g	7.54	77 a	3.50 b
LSD $_{(0.05)}$	NS	2.62	1.07
CV (%)	6.51	5.73	8.06

Means followed by the same letter in a column did not differ significantly at the 5% level by DMRT. NS= Not significant.

The benefit cost ratio (BCR), the highest gross return (Tk.985630/ha)) was recorded in 20 g bulb size but the highest net return (Tk.673255/ha) and benefit cost ratio (3.20) obtained from 15 g bulb size (Table 4). The lowest gross return (Tk.658500/ha), net return (Tk.408220/ha) and benefit cost ratio (2.69) was observed in 10 g bulb size (Table 4).

Table 4: BCR of bulb size on the seed yield of BARI Piaj-1

Treatment (Bulb size)	Seed yield (kg/ha)	Gross return (Tk./ha)	Total cultivation cost (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
B_1=10 g	658.50	658500	250280	408220	2.69
B_2=15 g	978.83	978830	305575	673255	3.20
B_3=20 g	985.63	985630	350270	635360	2.84

Urea= Tk.20/kg
TSP= Tk.22/kg
MoP=Tk.15/kg
Gypsum=Tk. 8/kg
Zinc oxide=Tk.120/kg
Boric acid=Tk.250/kg
Cowdung=Tk.2.5/kg
Rovral= Tk.2200/kg
Admire= Tk.6800/l
Labour=Tk.200/man/day
Irrigation= Tk.2250/ha/irrigation
Seed bulb= Tk.45/kg
Lease value of land= Tk.22500/ha for 5 months
Onion seed= Tk.1000/kg

Seed yield was 985.63 kg/ha when the bulb size was 20 g followed by 978.83 kg/ha in bulb size 15 g. But the maximum germination (78%), lower seed borne infection (3.31%) and higher economic return was obtained from the bulb size 15 g. Similar results were reported by many researchers (Jones and Mann, 1963 [9]; Arakeri and Patil, 1965 [3]; Pall and Padda, 1972[13]; Mondal and Choudhury, 1980 [12] and Abedin *et al*., 1999 [1]). Rahim (1991) [14] reported that the large size bulb produce higher seed yield. Hoque (1992) [7] reported that the highest weight of seed/plant gave from the bulb size 15 g. Brewster (1994) [6] opined that the continuous use of small size bulbs may reduce the seed quality of onion.

6. Conclusion

Based on the results of the experiment, optimum bulb size is 15 g recommended for true seed production of onion at Bogra region in Bangladesh.

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