

Effect of Bulb Size and Spacing on Seed Production of Onion

AV GINOYA^{1*}, JB PATEL², AS JETHVA³ AND IR DELVADIYA¹

¹College of Agriculture, JAU, Junagadh, ²Department of Seed Science and Technology, College of Agriculture, JAU, Junagadh, ³Vegetable Research Station, JAU, Junagadh, Gujarat - 362001, India

*aartiginoaya3347@gmail.com

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Onion (*Allium cepa* L.) is one of the most important commercial vegetable crop belongs to family *Amaryllidaceae* (*Alliaceae*) cultivated extensively in India. It is widely grown herbaceous biennial vegetable crop with cross pollinated and monocotyledonous behavior having diploid chromosome number $2n=16$ [1]. Onion is different from the other edible species of *Alliums* for its single bulb and is usually propagated by true botanical seed. The main edible portion of the onion plant is the bulb, which is a modified organ constituted by the thickened fleshy leaf sheaths and stem plate. Onion has also preservative and medicinal value. It is used to relieve insect bites and sore throat [2].

Every year the area under onion cultivation in India is increasing, but the farmers are facing the shortage of high quality seeds. Generally, onion seed is produced from planting mother bulbs. Onion seed price is directly proportional to onion bulb price used for growing seed crop [3]. Bulb-to-seed method is appropriate for onion seed production [4]. Planting bulb of optimum size, plant spacing, nutrient application and a suitable sowing date are considered to be the main factors influencing seed yield and quality [5]. Bulb size and plant spacing are the key factors in producing quality onion seeds [6]. Therefore, the present study was conducted to investigate the effects of bulb size and plant spacing on seed production of onion.

The present investigation was conducted at the Sagdividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh during *rabi* 2016-17 with an aim to study the effect of bulb size [B_1 (25 ± 5 g, small size), B_2 (50 ± 5 g, medium size) and B_3 (75 ± 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 yield per plant of onion cv. Gujarat Junagadh White Onion 3 (GJWO 3). The experiment was laid out in field as per randomized block design (Factorial) with three replications. The characters *viz.*, days to emergence, plant height (cm), number of green leaves per plant, number of tillers per plant, length of flowering stalk (cm), number of umbels per plant, umbel diameter (cm), number of flowers per umbel, number of seeded fruits per umbel, seed weight per umbel (g), seed yield per plant (g), seed yield per hectare (kg) and test weight (g) were recorded and analyzed. Analysis of variance for Randomized Block Design (Factorial) was computed as per the method of Cochran and Cox [7].

The analysis of variance for seed yield per plant and its components revealed that different bulb size and plant spacing treatments manifested significant differences for seed yield per plant and its component traits. *Mean squares* due to interaction effects of *bulb size and plant spacing* were found non-significant for seed yield per plant and its components.

The results revealed that significantly the earliest emergence (4.33 days) was recorded in bulb size 75 ± 5 g (B_3). Significantly early bulb emergence (4.56 days) was recorded in bulbs planted at a spacing of 60 cm x 40 cm (S_6) and it was at par with 60 cm x 30 cm (S_5) (4.89 days) and 45 x 40 cm (S_4) (5.00 days) (Table 1). Early plant emergence from larger bulb may be attributed to the higher sprouted leaf initials, inner and outer rooting as well as greater availability of amino acid and proteins after metabolism from higher quantity of food material available in large size bulbs. In wider spacing, bulbs get more roots forming area, resulting in early emergence. The results obtained in the present investigation are in accordance with the findings of Asaduzzaman *et al.* [8],

Table 1. Effect of bulb size and spacing on days to emergence, plant height (cm), number of green leaves per plant and number of tillers per plant in onion

Treatments	Days to Emergence	Plant height (cm)	Number of green leaves per plant	Number of tillers per plant
Bulb size (BS)				
B ₁ = 25 ± 5 g	6.00	36.73	17.29	4.21
B ₂ = 50 ± 5 g	5.78	38.99	19.12	5.87
B ₃ = 75 ± 5 g	4.33	40.59	21.16	6.86
SEm(±)	0.14	0.81	0.46	0.14
CD (p=0.05)	0.41	2.29	1.31	0.42
Spacing (S)				
S ₁ = 30 cm x 30 cm	6.56	42.57	17.70	5.20
S ₂ = 30 cm x 40 cm	6.00	39.69	18.20	5.33
S ₃ = 45 cm x 30 cm	5.22	38.54	19.33	5.69
S ₄ = 45 cm x 40 cm	5.00	37.87	19.51	5.57
S ₅ = 60 cm x 30 cm	4.89	37.55	20.02	5.91
S ₆ = 60 cm x 40 cm	4.56	36.39	20.36	6.02
SEm(±)	0.20	1.13	0.64	0.20
CD (p=0.05)	0.59	3.24	1.88	0.59
CV (%)	11.40	8.73	10.10	10.85
Interaction CD (p=0.05)	NS	NS	NS	NS

as they reported early sprout emergence in large size bulbs planted at wider plant spacing (100 plants per 6 m² area).

The larger bulb size of 75 ± 5 g (B₃) produced significantly tallest plant (40.59 cm) than that of smaller bulb size of 25 ± 5 g (B₁) (36.73 cm) (Table 1). Larger bulb size had enough reserve food to support growth of plants which resulted in the maximum plant height. This result agrees with the finding of Khodadadi [9]. Plants raised with the closest spacing of 30 cm x 30 cm (S₁) attained the maximum plant height (42.57 cm). These results could be attributed to the effect of narrow spacing on the reduction of light intensity, which encouraged IAA synthesis [10]. The increase in IAA concentration in stem tissues caused cell enlargement and hence, plant height [11]. The plant height decreased with increased in spacing. The results are in accordance with the findings of Barman *et al.* [12] and Elhag and Osman [13], as they recorded the maximum plant height at closer spacing.

The onion bulb with bulb size of 75 ± 5 g (B₃) produced significantly more number of green leaves per plant (21.16) and it was found to decrease with decrease in bulb size (Table 1). The results are in conformity with the results of Asaduzzaman *et al.* [14], Ali *et al.* [15] and Haile *et al.* [16], who noted the maximum number of

green leaves per plant from large bulbs. Significantly, the highest number of green leaves (20.36) was recorded from the plants sown at widest spacing of 60 cm x 40 cm (S₆) (Table 1). Plants of the widest spacing produced more green leaves probably due to less competition for nutrients, light, space and moisture. Barman *et al.* [12], Elhag and Osman [13] and Kumar *et al.* [17] also recorded higher number of leaves in wider spacing.

Significantly, the maximum number of tillers per plant (6.86) was produced by the large sized bulb (75 ± 5 g), which was remarkably different from the medium (5.87) and the small ones (4.21) (Table 1). The result confirms the finding of Ashrafuzzaman *et al.* [18], who found significantly higher number of tillers per plant from larger bulb. The maximum number of tillers per plant (6.02) was produced by the plants having the widest spacing of 60 cm x 40 cm (S₆). Begum *et al.* [19] also reported that wider spacing significantly increased the number of tillers per plant.

Plant raised from larger bulb (75 ± 5 g) produced significantly greater length of flowering stalk (65.55 cm) (Table 2). This finding is similar to the results obtained by Jagtap *et al.* [20] and El-Damarany *et al.* [21], who noted that flower stalk height of onion varied with bulb size, and it might be due to the presence of more stored

Table 2. Effect of bulb size and spacing on length of flowering stalk (cm), number of umbels per plant, umbel diameter and number of flowers per umbel in onion

Treatment	Length of flowering stalk (cm)	Number of umbels per plant	Umbel diameter (cm)	Number of flowers per umbel
Bulb size (BS)				
B ₁ = 25 ± 5 g	57.90	4.10	7.32	383.63
B ₂ = 50 ± 5 g	63.00	5.67	7.61	416.60
B ₃ = 75 ± 5 g	65.55	6.62	8.12	423.83
SEm(±)	1.26	0.13	0.16	9.29
CD (p=0.05)	3.61	0.36	0.45	26.72
Spacing (S)				
S ₁ = 30 cm x 30 cm	58.28	5.00	7.19	373.89
S ₂ = 30 cm x 40 cm	59.33	5.11	7.32	382.13
S ₃ = 45 cm x 30 cm	62.37	5.49	7.48	409.60
S ₄ = 45 cm x 40 cm	62.71	5.57	7.71	414.60
S ₅ = 60 cm x 30 cm	64.54	5.71	8.15	430.20
S ₆ = 60 cm x 40 cm	65.66	5.89	8.25	437.71
SEm(±)	1.77	0.18	0.22	13.13
CD (p=0.05)	5.11	0.51	0.64	37.78
CV (%)	8.57	9.81	8.71	9.66
Interaction CD (p=0.05)	NS	NS	NS	NS

food inside large bulbs eventually contributing to the emergence of long flower stalks. The onion bulb having the widest spacing of 60 cm x 40 cm (S₆) produced on an average significantly tallest flowering stalk (65.66 cm), Length of flowering stalk increased with the increased in plant spacing. This might be due to that widest plant spacing produced more green leaves and extra food, which later may encourage the length of flowering stalk. The results are in accordance with the findings of Asaduzzaman *et al.* [22].

Significantly, the highest number of umbels per plant (6.62) was produced by the bulbs having a largest size (75 ± 5 g), while significantly the lowest number of umbels per plant (4.10) was noted in the smallest sized bulb (25 ± 5 g) (Table 2). Increase in number of umbels per plant with the rise in bulb size in onion was also reported earlier by Asaduzzaman *et al.* [22], Ali *et al.* [15] and Debashis *et al.* [23]. Significantly the maximum number of umbels per plant (5.89) was produced by the bulb spaced at the widest spacing of 60 cm x 40 cm (S₆) (Table 2). Similar results were also noted by Asaduzzaman *et al.* [22] and Elhag and Osman [13] in onion.

The results indicated that different bulb size and spacing exerted significant influence on umbel diameter (Table 2). Plants emerged out from the large bulbs 75 ± 5 g

(B₃) produced significantly the highest umbel diameter (8.12 cm), while significantly the lowest bulb diameter (7.32 cm) was produced in the plants of the smallest bulb size 25 ± 5 g (B₁). Similar findings were also reported earlier in onion by Asaduzzaman *et al.* [22], Khodadadi [9], Teshome *et al.* [24], Ali *et al.* [15], El-Damarany *et al.* [21] and Mollah *et al.* [25]. The closest spacing 30 cm x 30 cm (S₁) produced umbels having significantly the lowest diameter (7.19), while the wider spacing 60 cm x 40 cm (S₆) produced umbels having significantly the highest diameter (8.25 cm). The findings are in accordance with the work of Asaduzzaman *et al.* [14] and Kumar *et al.* [17].

Significantly, the highest numbers of flowers per umbel (423.83) were observed with the largest bulb size 75 ± 5 g (B₃) (Table 2). The results are in akin to those reported by Asaduzzaman *et al.* [14] and Mollah *et al.* [25] in onion. Significant increase in the number of flowers per umbel (437.71) was obtained from the bulbs spaced at the widest spacing of 60 cm x 40 cm (S₆). This might be due to that the widest spacing produced the largest length and diameter of umbel by uptake more nutrients, which ultimately encourage the production of the highest number of flowers per umbel. Asaduzzaman *et al.* [22] and Asaduzzaman *et al.* [8] also reported the same results in onion for this trait.

Bulbs weighing 75 ± 5 g (B_3) produced significantly the highest number of seeded fruits per umbel (329.70) (Table 3). Asaduzzaman *et al.* [14] and Mollah *et al.* [25] stated that number of seeded fruits per umbel was affected by bulb size and it was observed higher in plants raised from larger bulb. Significant increase in the number of seeded fruits per umbel (347.09) was obtained from the bulbs spaced at the widest spacing of 60 cm x 40 cm (S_6) and it was found statistically at par with 60 cm x 30 cm (S_5) (339.20), 45 cm x 40 cm (S_4) (321.86) and 45 cm x 30 cm (S_3) (315.09). Asaduzzaman *et al.* [22] and Asaduzzaman *et al.* [8] also reported the same results in onion for this trait. However, relatively the maximum number of seed fruits per umbel was recorded in the treatment combinations $B_3 \times S_6$ (361.87) followed by $B_2 \times S_6$ (357.54) and $B_3 \times S_5$ (351.87).

The maximum seed weight per umbel (1.20 g) was recorded in the plants raised from largest bulb size 75 ± 5 g (B_3) and 50 ± 5 g (B_2) (Table 3). Increase in seed weight per umbel with the increase in bulb size was also reported by Asaduzzaman *et al.* [22] and Debashis *et al.* [23]. Of the six plant spacing, the widest spacing of 60 cm x 40 cm (S_6) gave significantly the highest weight of seeds per umbel (1.28 g) which was markedly superior to the seed weight per umbel under other spacing. Similar inference was also drawn earlier by Asaduzzaman *et al.* [22].

Significantly, the highest seed yield per plant (8.05 g) was obtained in the plants raised from the largest bulb size 75 ± 5 g (B_3) (Table 3), Higher number of flowers per umbel and per plant caused by the highest sized bulbs increased the seeded fruits and finally seed weight per umbel as well as per plant. The determined results are in agreement with the results of Jagtap *et al.* [21] and Debashis *et al.* [23] in onion. Significantly the highest seed yield per plant (7.55 g) was produced by the bulbs spaced at the widest spacing of 60 cm x 40 cm (S_6). Elhag and Osman [13] and Kumar *et al.* [17] observed significantly the maximum seed yield per plant in wider spacing as against the closest spacing.

The seed yield per hectare exactly followed the same declining trend with the decrease in bulb size as found in seed yield per plant, because the seed yield per hectare was calculated on the basis of seed yield per plant and converted to seed yield per hectare and analyzed (Table 3). The largest bulb 75 ± 5 g (B_3) produced significantly the highest seed yield per hectare (501.87 kg). Higher number of flowers per umbel and per plant caused by the largest sized bulbs increased the seeded fruits and finally seed weight per umbel as well as seed yield per plant, per plot and per hectare. The results are in accordance to the findings of Ali *et al.* [15], El-Damarany *et al.* [21], Mollah *et al.* [25] and

Table 3. Effect of bulb size and spacing on number of seeded fruits per umbel, seed weight per umbel (g), seed yield per plant (g), seed yield per hectare (kg) and test weight (g) in onion

Treatment	Number of seeded fruits per umbel	Seed weight per umbel (g)	Seed yield per plant (g)	Seed yield per hectare (kg)	Test weight (g)
Bulb size					
$B_1 = 25 \pm 5$ g	288.20	1.06	4.45	288.78	3.83
$B_2 = 50 \pm 5$ g	325.59	1.20	6.91	394.27	3.93
$B_3 = 75 \pm 5$ g	329.70	1.20	8.05	501.87	4.13
SEm(±)	9.83	0.03	0.25	14.09	0.05
CD (p=0.05)	28.28	0.10	0.71	40.54	0.13
Spacing					
$S_1 = 30$ cm x 30 cm	277.09	1.03	5.23	426.77	3.83
$S_2 = 30$ cm x 40 cm	286.64	1.05	5.54	412.87	3.85
$S_3 = 45$ cm x 30 cm	315.09	1.16	6.53	435.09	3.91
$S_4 = 45$ cm x 40 cm	321.86	1.19	6.72	396.23	3.98
$S_5 = 60$ cm x 30 cm	339.20	1.24	7.25	362.05	4.06
$S_6 = 60$ cm x 40 cm	347.09	1.28	7.55	336.84	4.14
SEm(±)	13.90	0.05	0.35	19.93	0.06
CD (p=0.05)	39.99	0.14	1.00	57.32	0.18
CV (%)	13.26	12.63	16.12	15.14	4.79
Interaction CD (p=0.05)	NS	NS	NS	NS	NS

Debashis *et al.* [23], who reported that the large size bulb produced the higher seed yield per hectare. Analysis of data presented in Table 3 showed that different plant spacing had produced significant influence on seed yield per hectare. Due to conversion of per plot yield into per hectare yield, seed yield per hectare was found significantly the highest (435.09 kg/ha) in medium spacing of 45 cm x 30 cm (S_3) and it was found at par with spacing of 30 cm x 30 cm (S_1), 30 cm x 40 cm (S_2) and 45 cm x 40 cm (S_4) with 426.77, 412.87 and 396.23 kg/ha seed yield, respectively. The results are in agreement with findings of Asaduzzaman *et al.* [22] and El Abas *et al.* [26].

The data showed that the large bulb size 75 ± 5 g (B_3) gave significantly the highest test weight of the seed (4.13 g) and the lowest (3.83 g) by the smallest bulb 25 ± 5 g (B_1) (Table 3). High food reserves present in the large bulb might supply nutrient properly to the seeds, which perhaps cause the highest weight of 1000 seed. These findings are in agreement with the findings of Asaduzzaman *et al.* [22], Ali *et al.* [15], El-Damarany *et al.* [21] and Mollah *et al.* [25]. The weight was noted significantly the highest (4.14 g) for the bulbs planted at wider spacing 60 cm x 40 cm (S_6) and it was at par with spacing of 60 cm x 30 cm (S_5) (4.06 g) and 45 cm x 40 cm (S_4) (3.98 g). This might be due to the fact that the wider spacing supplied more food materials to the growing seeds compared to the closest spacing. The results are in agreement with the findings of Asaduzzaman *et al.* [22], Kumar *et al.* [17] and El Abas *et al.* [26] in onion.

From the results, it can be concluded that bulb size and plant spacing played important role on plant growth and seed yield of onion. Looking to the effect of bulb size and spacing, it is suggested that large size onion bulbs of Gujarat White Onion 3 (GJWO 3) should be planted at the spacing of 45 cm x 30-40 cm for getting higher seed yield.

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