http://www.pjbs.org

PJBS

ISSN 1028-8880

# Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences, 2 (4): 1143-1146, 1999 Research Article

# Effect of Different Set Sizes, Spacings and Nitrogen Levels on the Growth and Bulb Yield of Onion

M.K. Islam, M.A. Awal*, S.U. Ahmed and M.A. Baten*
Department of Horticulture, * Department of Crop Botany,
Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

## Abstract

Influence of two set sizes viz. 1.6 and 2.44 g/set, three plant spacings viz. 20cm x 10cm, 20cm x 15cm and 20cm x 20 cm and four doses of N viz. 0, 60,120 and 180 kg/ha on the growth and bulb yield of onion was studied. Larger set produced the highest bulb yield (22.6 t/ha) over smaller one (19.9 t/ha) . Smaller set gave more number of single bulbs and took shorter growing period. The closest spacing produced the maximum number of single bulbs (31.6%) and the highest bulb yield (23.7 t/ha). N at zero level gave the highest number of single bulbs. N at 120 kg/ha produced the maximum bulb yield (28.5 t/ha), but N at 180 kg/ha gave the highest plant height and required the longest growing period. Interaction effects of all possible combinations caused significant variation on bulb yield and related components. Larger set with the closest spacing gave the highest bulb yield (25.6 t/ha). Smaller set with nitrogen at zero level produced the maximum number of single bulbs. The closest spacing with 120 N/ha gave the highest bulb yield (31.6 t/ha). Maximum bulb yield (33.7 t/ha) was recorded from the combination of larger set x closest spacing x 120 kg N/ha. Smaller set 'x closest spacing x zero level N produced the highest number of single bulbs.

## Introduction

Onion (*Allium cepa* L.) ranks first in terms of area and production amongst the bulb crops in the world and in Bangladesh it covers about 34413 hectares of land with an average yield of 4.13 t $ha^{-1}$ (Anonymous, 1997a,b). With the tremendous increase of population, the onion demand in Bangladesh is increasing day by day, but the horizontal cultivation is not increasing at the same rate due to limitation of land. So, the intensive onion cultivation is essential to meet up the over increasing demand in Bangladesh. About 30 percent of the onion grown in Bangladesh are produced from sets and the rest are produced through bulb transplanting and direct seed sowing (Rahim *et al*., 1992). To obtain early market price in the crisis period, onion production from set to bulb is very much effective. By this method bulb matured about 3 to 4 weeks earlier than those from seeds, but it involves high cost compared to the other methods (Jones and Mann, 1963). However, early market price compensates the production cost.

Like other crop plants, onion production is greatly influenced by the environmental factors, cultivars and agronomic practices (Mondal *et al*., 1986). Among the agronomic practices set size, spacing and nitrogen fertilization play an important role to reach the optimum yield potential. Set size and spacing influence the plant growth, bulb size, splitting of bulb, yield as well as the quality of the produce (Purewal and Dargan, 1962; Nichols and Heydecker, 1964; Shalaby *et al*., 1991). Nitrogen is essential to increase the bulb size and yield (Singh and Kumar, 1969), but excessively high doses of nitrogen cause delay in bulb maturity, increase leaf growth and decrease the bulb yield (Riekels, 1977). But the information in this regard on onion production is hardly available in Bangladesh.

Therefore, the present study was carried out with two set sizes, three plant spacings and four doses of nitrogen to find out their effects on the bulb yield and related characters in onion under the existing agroclimatic conditions of Bangladesh.

## Materials and Methods

The experiment on onion (cv.Taherpuri) was conducted at Bangladesh Agricultural University, Mymensingh, Bangladesh during 1997 - 1998 cropping season. The onion sets were collected from Taherpur, Bagmara, Rajshahi, Bangladesh for this experiment. Two different set sizes viz. smaller (1.6 g/set) and larger (2.44 g/set), three plant spacings viz. 20cm x 10cm, 20cm x 15cm and 20cm x 20cm and four levels of nitrogen viz. $N_0$ (0 kg), $N_{60}$ (60 kg), $N_{120}$ (120 kg) and $N_{180}$ (180 kg)/ha were applied in the experiment following randomized complete block design (RCBD) with three replications. The unit plot size was 1.2m x 1.0m. The total amount of well decomposed cowdung (5 t/ha), triple super phosphate (130 kg/ha) and muriate of potash (160 kg/ha) were applied during the land preparation (Anonymous, 1997c). Urea was applied as the source of nitrogen as per treatment and top dressed along the line after 20 days of set planting. The planting was done on October 30, 1997 as per treatment schedule. Intercultural operations like gap filling, weeding, irrigation, plant protection etc were done as and when required.

Ten plants were randomly selected from each plot in such a way that the border effect was avoided for the highest precision and the data recorded on plant height (cm), leaf number per plant, types of bulb (% single and splitted), bulb length (cm), bulb diameter (cm), bulb fresh weight (g/plant), per cent bulb dry matter, days to bulb harvest and bulb yield (t $ha^{-1}$). All data were statistically analyzed and the mean values were adjudged with DMRT.

## Results and Discussion

**The main effects:** The set size significantly influenced the growth and bulb yield of onion and the results are presented in Table 1. Larger set produced taller plant, more number of leaves per plant, higher bulb length, bulb diameter, splitted bulb, bulb fresh weight, bulb dry matter content and bulb yield as compared to the smaller one. Longer duration from planting to bulb harvest was taken by the larger sets. Such results produced by the larger sets might be due to more

Table 1: Main effects of set sizes, spacings and N levels on the growth and bulb yield of onion

| Treatments | Plant height (cm) | No. of leaves plant | Types of bulb (%) | | Bulb length (cm) | Bulb diameter (cm) | Bulb fresh weight (g/plant) | Bulb dry matter (%) | Days to bulb harvest | Bulb yield (t/ha) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Single | Splitted | | | | | | |
| **Set size** | | | | | | | | | | |
| Smaller | 49.1b | 10.7b | 29.9a | 70.1b | 4.1b | 4.3b | 55.1b | 13.4b | 105.6b | 19.9b |
| Larger | 52.2a | 13.0a | 24.8b | 75.2a | 4.2a | 4.6a | 64.2a | 13.9a | 108.4a | 22.6a |
| **Plant spacing** | | | | | | | | | | |
| 20cm x 10cm | 47.6b | 10.8c | 31.6a | 68.4c | 3.8b | 4.2c | 50.3c | 13.4b | 105.8c | 23.7a |
| 20cm x 15cm | 50.1a | 11.7b | 27.6b | 72.4b | 4.2a | 4.5b | 61.2b | 13.8a | 107.1b | 21.6b |
| 20cm x 20cm | 51.9a | 13.0a | 22.7c | 77.2a | 4.3a | 4.7a | 67.4a | 13.7a | 108.1a | 18.5c |
| **N (kg/ha)** | | | | | | | | | | |
| 0 | 43.2d | 9.3d | 44.6a | 55.3d | 3.3d | 3.8d | 40.5d | 12.1d | 95.6d | 13.2d |
| 60 | 50.2c | 11.4c | 27.2b | 72.7c | 4.4b | 4.6b | 61.1c | 13.4c | 105.5c | 20.6c |
| 120 | 52.8b | 12.7b | 22.7c | 77.3b | 4.6a | 5.1a | 73.0a | 14.9a | 111.5b | 28.5a |
| 180 | 54.5a | 14.1a | 14.6d | 85.4a | 4.1c | 4.3c | 63.9b | 14.2b | 115.4a | 22.8b |

In a column figures having no common letter(s) differ significantly at 1% level

Table 2: Interaction effects of set sizes and spacings on the growth and bulb yield of onion

| Treatments | Plant height (cm) | No. of leaves plant | Types of bulb (%) | | Bulb length (cm) | Bulb diameter (cm) | Bulb fresh weight (g/plant) | Bulb dry matter (%) | Days to bulb harvest | Bulb yield (t/ha) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Single | Splitted | | | | | | |
| **Smaller set** | | | | | | | | | | |
| 20cm x 10cm | 46.3d | 9.4f | 34.5a | 65.6d | 3.3c | 4.1d | 44.3d | 13.0d | 104.8c | 21.8c |
| 20cm x 15cm | 50.5b | 10.9e | 29.3b | 70.6c | 4.1b | 4.4c | 56.4c | 13.6bc | 105.3c | 20.5d |
| 20cm x 20cm | 50.6b | 11.8d | 25.6c | 74.1b | 4.3ab | 4.5b | 64.6b | 13.5c | 106.6b | 7.5f |
| **Larger set** | | | | | | | | | | |
| 20cm x 10cm | 48.9c | 12.2c | 28.8b | 71.3c | 3.9c | 4.3c | 56.3c | 13.8ab | 106.8b | 25.6a |
| 20cm x 15cm | 51.7b | 12.6b | 25.9c | 74.1b | 4.3ab | 4.6b | 66.0b | 14.0a | 108.9a | 22.7b |
| 20cm x 20cm | 53.1a | 14.3a | 19.8d | 80.4a | 4.4a | 4.8a | 70.3a | 13.8a | 109.6a | 19.6e |
| Sig. level | 0.05 | 0.01 | 0.01 | 0.05 | 0.05 | 0.05 | 0.01 | 0.01 | 0.01 | 0.01 |

In a column figures having no common letter(s) differ significantly

Table 3: Interaction effects of set sizes and N levels on the growth and bulb yield of onion

| Treatments | | Plant height (cm) | No. of leaves plant | Types of bulb (%) | | Bulb length (cm) | Bulb diameter (cm) | Bulb fresh weight (g/plant) | Bulb dry matter (%) | Days to bulb harvest | Bulb yield (t/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Single | Splitted | | | | | | |
| **Smaller set** | | | | | | | | | | | |
| N (kg/ha) = | 0 | 42.1f | 8.5f | 48.1a | 51.8g | 3.2f | 3.7g | 36.7f | 11.7f | 93.8h | 11.9g |
| | 60 | 49.3d | 9.9e | 29.6c | 70.1e | 4.3bc | 4.4d | 55.0d | 13.3d | 104.4f | 19.3e |
| | 120 | 51.7c | 11.5d | 24.7d | 75.3d | 4.6a | 5.0b | 68.8b | 14.7b | 110.3d | 27.4b |
| | 180 | 53.5b | 12.7c | 16.8f | 83.2b | 4.1d | 4.2e | 59.7c | 13.8c | 113.6b | 21.2d |
| **Larger set** | | | | | | | | | | | |
| N (kg/ha) = | 0 | 44.3e | 10.0e | 41.2b | 58.8f | 3.5e | 3.9f | 44.2e | 12.4e | 97.3g | 14.6f |
| | 60 | 51.2c | 12.8c | 24.8d | 75.3d | 4.5ab | 4.7c | 67.2b | 13.5d | 106.6e | 22.0d |
| | 120 | 53.8b | 13.8b | 20.8e | 79.2c | 4.6a | 5.3a | 77.1a | 15.0a | 112. 7c | 29.7a |
| | 180 | 55.6a | 15.5a | 12.4g | 78.6a | 4.2cd | 4.4d | 68.1b | 14.6b | 117.1a | 24.3c |
| **Siq. level** | 0.05 | 0.01 | 0.01 | 0.05 | 0.05 | 0.05 | 0.05 | 0.01 | 0.05 | 0.05 | |

In a column figures having no common letter(s) differ significantly

food materials stored in the larger set which enhanced vigorous plant growth, taller plants, more number of leaves per plant, higher splitted bulbs, higher bulb yield and prolonged the growing period. Similar results were also reported by Lazic (1975) and Shalaby *et al*. (1991).

The growth and yield of onion plant were significantly affected by plant spacing (Table 1). The highest plant spacing (20cm x 20cm) gave the maximum plant height, leaf number per plant, splitted bulb, bulb length, bulb diameter, bulb weight per plant and dry matter content of bulb. Plants grown at the highest spacing required the longest growing period. But the lowest spacing (20 cm x 10 cm) significantly produced the maximum single bulb and bulb yield. The plants grown at the highest spacing received more soil water, mineral nutrients and solar radiation under less interplant competition which promoted vigorous growth and growing period resulting in positive improvement of leaf and bulb traits. The results are best fit with the findings of Badaruddin and Haque (1977) and Rizk *et al*. (1991). The plants grown under minimum spacing produced more bulb yield which might have been due to the higher number of plants accommodated in a unit land area. Purewal and Dargan (1962) and Nichols and Heydecker (1964) also obtained the similar results.

Increasing nitrogen levels were found to increase plant height significantly (Table 1). The maximum plant height was recorded in plants grown with N180 (180 kg N/ha) and the minimum at $N_o$. The highest dose of nitrogen also produced the highest number of leaves per plant. Such results showed similarity with the findings of Vachhani and

Table 4: Interaction effects of spacings and N levels on the growth and bulb yield of onion

| Treatments | Plant height (cm) | No. of leaves plant | Types of bulb (%) | | Bulb length (cm) | Bulb diameter (cm) | Bulb fresh weight (g/plant) | Bulb dry matter (%) | Days to bulb harvest | Bulb yield (t/ha) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Single | Splitted | | | | | | |
| **Spacing : 20cm x 10cm** | | | | | | | | | | |
| N (kg/ha) = 0 | 37.4g | 8.7f | 50.6a | 49.4i | 3.0g | 3.2f | 35.3i | 12.2e | 93.0g | 15.0g |
| 60 | 48.8de | 10.3e | 30.1d | 70.0f | 3.9e | 4.3d | 48.3g | 13.2d | 104.5e | 22.8d |
| 120 | 50.9bcd | 11.3d | 27.9e | 72.1e | 4.4bc | 4.8c | 61.1e | 14.5b | 111.0c | 31.6a |
| 180 | 53.2ab | 12.9c | 17.9h | 82.2c | 4.0b | 4.3d | 56.3f | 13.8c | 114.5b | 25.4c |
| **Spacing : 20cm x 15cm** | | | | | | | | | | |
| N (kg/ha) =0 | 45.2f | 9.2f | 45.8b | 54.0 h | 3.4f | 4.0e | 40.3 h | 12.0 e | 96.2 f | 13.4 h |
| 60 | 50.3cd | 13.3d | 27.5e | 72.5e | 4.6ab | 4.6c | 62.2de | 13.6c | 105.3de | 20.8e |
| 120 | 54.1a | 12.7c | '22.5g | 77.5d | 4.8a | 5.1b | 76.5b | 15.0a | 1 12.0c | 28.4b |
| 180 | 54.8a | 13.8b | 14.51 | 85.5b | 4.1de | 4.2d | 65.7d | 14.5b | 115.0b | 23.9b |
| **Spacing : 20cm x 20cm** | | | | | | | | | | |
| N (kg/ha) =0 | 47.0ef | 10.0e | 37.5c | 62.5g | 3.6f | 4.2ab | 45.7g | 12.0e | 97.5f | 11.3i |
| 60 | 51.5bc | 12.5c | 24.1f | 75.7d | 4.7a | 4.8c | 72.8bc | 13.3d | 106.7d | 18.3f |
| 120 | 53.3ab | 14.1b | 17.8h | 82.3c | 4.8a | 5.5a | 81.3a | 15.0a | 111.5c | 25.6c |
| 180 | 55.6a | 15.6a | 11.5j | 88.5a | 4.3cd | 4.4d | 69.8c | 14.3b | 116.7a | 19.0f |
| **Sig. level** | 0.01 | 0.01 | 0.05 | 0.05 | 0.05 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |

In a column figures having no common letter(s) differ significantly

Table 5: Interaction effects of set sizes, spacings and N levels on the growth and bulb yield of onion

| Treatments | Plant height (cm) | No. of leaves plant | Types of bulb (%) | | Bulb length (cm) | Bulb diameter (cm) | Bulb fresh weight (g/plant) | Bulb dry matter (%) | Days to bulb harvest | Bulb yield (t/ha) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Single | Splitted | | | | | | |
| **Smaller set and 20cm x 10cm** | | | | | | | | | | |
| N (kg/ha) =0 | 36.3m | 8.1j | 54.7a | 45.3m | 2.8j | 3.0 1 | 29.7b | 11.4e | 91.0m | 13.9op |
| 60 | 48.0 jk | 9.21 | 32.6g | 67.4hj | 3.9fg | 4.3hi | 45.5ij | 13.1c | 104.0j | 21.1hi |
| 120 | 49.2 hij | 9.5h1 | 30.0h | 70.0gh | 4.3cde | 4.8ef | 54.2g | 14.2b | 110.0g | 29.4b |
| 180 | 51.6 d-h | 10.8g | 20.5m | 79.5c | 3.9fg | 4.2hi | 47.6hi | 13.3c | 114.0cd | 22.5gh |
| **Smaller set and 20cm x 15cm** | | | | | | | | | | |
| N (kg/ha) =0 | 44.5 l | 8.3j | 49.6b | 50.41 | 3.4h1 | 3.9j | 30.1k | 11.9de | 94.31 | 21.7q |
| 60 | 49.4 g-j | 9.8 hi | 28.5hi | 71.5fg | 4.5a-d | 4.5gh | 49.2hi | 13.4c | 104.0j | 19.5jk |
| 20 | 53.8 b-e | 12.2f | 23.6e | 76.5de | 4.7ab | 5.0cd | 74.9bc | 14.9a | 1 10.Og | 27.8bc |
| 180 | 54.5 a-d | 13.2e | 15.5n | 84.5b | 4.0e-g | 4.01j | 63.3f | 14.2b | 1 13.0de | 23.2fg |
| **Smaller set and 20cm x 20cm** | | | | | | | | | | |
| N (kg/ha) =0 | 45.5k1 | 9.31 | 40.0e | 60.0j | 3.4h-i | 4.1ij | 42.31k | 11.9d | 96.0 1 | 10.1r |
| 60 | 50.4 f-j | 11.9g | 28.6ij | 71.4fg | 4.6a-d | 4.6fg | 70.4d | 13.3c | 105.3ij | 17.21m |
| 120 | 52.2 c-g | 13.0e | 20.5m | 79.5c | 4.8a | 5.3b | 77.3b | 15.0a | 111.0fg | 24.9de |
| 180 | 54.3 a-d | 14.1d | 14.4no | 85.7b | 4.2d-f | 4.2hi | 68.3de | 13.9b | 1 14.0cd | 17.9k1 |
| **Larger set and 20cm x 10cm** | | | | | | | | | | |
| N (kg/ha) = 0 | 38.6m | 9.31 | 46.5c | 53.4k | 3.21 | 3.4k | 41.0k | 12.9c | 95.0 1 | 16.0 mn |
| 60 | 39.7f-j | 11.5g | 27.5ijk | 72.5fg | 4.0fg | 4.4gh | 51.1gh | 13.3c | 105.0ij | 24.5ef |
| 120 | 52.6 b-f | 13.2e | 25.8k | 74.2ef | 4.4bcd | 4.8de | 68.0de | 14.8a | 1 12.Oef | 33.7a |
| 180 | 54.8abc | 15.Obc | 15.2no | 84.8b | 4.0efg | 4.4gh | 65.0ef | 14.2b | 115.0c | 28.3b |
| **Larger set and 20cm x 15cm** | | | | | | | | | | |
| N (kg/ha) =0 | 45.8k1 | 10.1h | 42.0d | 58.0j | 3.5hi | 4.01j | 42.5jk | 12.1d | 98.0k | 15.1 no |
| 60 | 51.2 e-i | 12.9ef | 26.5jk | 73.5f | 4.7abc | 4.8def | 75.2bc | 13.9b | 106.0hi | 22.1gh |
| 120 | 54.4 a-d | 13.1e | 21.5m | 78.5cd | 4.8a | 5.3bc | 78.1b | 15.1a | 114.0cd | 29.1b |
| 180 | 55.2ab | 14.4cd | 13.5o | 86.5b | 4.2def | 4.4gh | 68.1de | 14.9a | 117.0b | 24.5ef |
| **Larger set and 20cm x 20cm** | | | | | | | | | | |
| N (kg/ha) =0 | 48.5ij | 10.8g | 35.0f | 65.0i | 3.7gh | 4.3 hi | 49.2 hi | 12.2d | 99.0k | 12.5pq |
| 60 | 52.5b-f | 14.1d | 20.5m | 80.0c | 4.8a | 4.9de | 75.3bc | 13.3c | 108.0h | 19.3jk |
| 120 | 54.5a-d | 15.3b | 15.Ono | 85.0b | 4.7abc | 5.7a | 85.3a | 15.1a | 1 12.Oef | 26.3cd |
| 180 | 56.8a | 17.0a | 10.0p | 90.0a | 4.3cde | 4.5gh | 71.3cd | 14.8a | 119.3a | 20.2ij |
| **Sig. level** 0.05 | 0.01 | 0.01 | 0.01 | 0.05 | 0.05 | 0.05 | 0.01 | 0.05 | 0.01 | |

In a column figures having no common letter(s) differ significantly

Patel (1993). $N_0$ and $N_{180}$ gave the minimum and maximum number of splitted bulbs, respectively. Higher nitrogen enhanced vegetative growth along with much tittering that resulted in more number of splitted bulbs. The highest dose of nitrogen (N180) prolonged the growing period. This result was supported well by the findings of Das and Dhyani (1956) who observed that bulb formation and maturity were delayed by excessive doses of nitrogen. Plants grown with 120 kg N/ha increased bulb length, bulb diameter and dry matter content of bulb. $N_{120}$ also produced the highest bulb yield of 28.5 t/ha followed by 22.8 and 20.6 t/ha produced by the plants having received $N_{180}$ and $N_{60}$,

respectively, while the minimum yield (13.2 t/ha) was noticed from the plants grown with $N_0$. It clearly indicated that bulb yield increased with the increasing level of nitrogen up to 120 kg N/ha and thereafter, it decreased with excessive level of nitrogen. Such lower yield produced by the highest dose of N might be due to excessive foliage growth thus prevented the proportionate distribution of assimilates to the bulb.

**The interaction effects:** The interaction effects of set size x spacing, set size x N levels, spacing x N levels, and set size x spacing x N levels on the growth and bulb yield of onion have been presented in Table 2, 3, 4 and 5 respectively. Smaller set with the lowest spacing produced the maximum number of single bulbs. Larger set with higher spacing required longer growing period. Larger set with the lowest spacing produced the highest bulb yield (25.6 t/ha), but larger set along with the highest spacing (20cm x 20cm) gave the maximum weight per bulb and splitted bulbs. Interaction effects of set sizes and N levels were also significant in all aspects of growth. Smaller set with $N_0$ produced the maximum number of single bulbs (48.1%). Combination of larger set and $N_{120}$ produced the maximum bulb yield (29.7 t/ha). Maximum number of days for growing period was taken by the combination of larger set and $N_{180}$. Interaction effects of spacing and N levels were significant on the bulb yield and most of the characters studied. Higher spacing in association with $N_{180}$ increased plant height, number of leaves per plant and splitted bulbs. The highest bulb yield (31.6 t/ha) was obtained from the lowest spacing along with $N_{120}$, but the larger sized bu,lbs were obtained from the combination of higher spacing (20cm x 20cm) and $N_{120}$.

Interaction effects of set size, plant spacing and N levels were also significant on the bulb yield and most of the characters under study. The highest bulb yield (33.7 t/ha) was observed from the combination of larger set x lowest spacing (20cm x 10cm) x $N_{120}$. The combination of smaller set, lowest spacing and $N_0$ gave the highest number (54.7%) of single bulbs and expanded lesser period for bulb harvest. Therefore, the best combination may be chosen as per requirement.

## References

Anonymous, 1997a. Annual report on spices research programme. Horticutre Division of Bangladesh, Agriculture Research Institute, Bangladesh, pp: 10.

Anonymous, 1997b. FAO Quarterly Bulletin of Statistics. Vol. 10, Food and Agricultural Organization, Rome, Italy, pp: 91-94.

Anonymous, 1997c. Statistical pocket book of Bangladesh. Bangladesh Bureau of Statistics. Ministry of Planning. Government of the People's Reuplic of Bangladesh, pp: 199.

Badaruddin, M. and M.A. Haque, 1977. Effect of time of planting and spacing on the yield of onion (*Allium cepa*). Bangladesh Hortic., 5: 23-29.

Das, B.C. and K.C. Dhyani, 1956. Influennce of differential spacing and nitrogen fertilization on growth and yield of onion. Phyton, 6: 47-56.

Jones, H.A. and L.K. Mann, 1963. Onions and their Allies: Botany, Cultivation and Utilization. Leonard Hill Ltd., New York, pp: 125.

Lazic, B., 1975. The effect of the size of the sets on the intensity of growth, maturity and qualitative properties of onion. Acta Hortic., 52: 259-262.

Mondal, M.F., J.L. Brewster, G.E.L. Morris and H.A. Butter, 1986. Bulb development in onion (*Allium cepa* L.) effects of plant density and sowing date in field conditions. Ann. Bot., 58: 187-195.

Nichols, M.A. and W. Heydecker, 1964. Onion sets at four by six gave the highest returns. Grower, 61: 1089-1089.

Purewal, S.S. and K.S. Dargan, 1962. Fertilizer and spacing experiments with onion crop. Indian J. Agorn., 7: 46-53.

Rahim, M.A., M.A. Hakim, A. Begum and M.S. Islam, 1992. Scope for increasing the total yield and fulfilling the demand for onions during the period of shortage in Bangladesh through the bulb-to-bulb (set) method of production. Onion Newslett. Trop., 4: 4-6.

Riekels, J.W., 1977. Nitrogen-water relationships of onions grown on organic soil. J. Am. Soc. Hortic. Sci., 102: 139-142.

Rizk, T.Y., M.T. Fayed, S.M. El-Nagar and H. Fawzy, 1991. Effect of plant spacing on growth, yield and its components of onion (*Allium cepa* L.). Egypt. J. Agron., 1991: 71-80.

Shalaby, G.I., A.I. El-Muraba, N.M. Kandeel and A.A. Gamie, 1991. Effect of some cultural practices on onion bulb production grown from sets. II: Plant density and set set-size. Assiut. J. Agric. Sci., 22: 83-101.

Singh, K. and S. Kumar, 1969. Effect of nitrogen and phosphorus fertilization on the growth and yield o onion (*Allium cepa* L.). JU. Res. Ludhiana, 6: 764-768.

Vachhani, M.U. and Z.G. Patel, 1993. Growth and yield of onion (*Allium cepa*, L.) as influenced by levels of nitrogen, phosphorus and potash under south Gujarat conditions. Prog. Hortic., 25: 166-167.