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EFFECT OF NITROGEN REGIMES ON THE YIELD AND QUALITY OF ONION (*Allium cepa* L.) THROUGH SET TO BULB METHOD

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Abstract

The experiment was conducted at the Spices Research Sub-Centre (SRSC), Bangladesh Agricultural Research Institute (BARI), Faridpur during winter season of 2023-2024 from October to January to find out the optimum dose of nitrogen for higher yield and quality of onion (var. BARI Piaz-4) through set to bulb method. The experiment comprised 7 levels of nitrogen, viz. T_2: 0 kg N/ha, T_2: 30 kg N/ha, T_3: 60 kg N/ha, T_4: 90 kg N/ha, T_5: 120 kg N/ha, T_6: 150 kg N/ha and T_7: 180 kg N/ha. The experiment was laid out in the Randomized Complete Block Design with three replications. The results revealed that characteristics studied were influenced by N regimes. Growing onion without N exhibited yellowing in colour on the leaves of plants under the score 5 significantly followed by 30 kg N/ha (score 3). While, onion plants receiving N @ 60-180 kg/ha had no sign of yellowing on the plant. Instead of yellowing, plants with higher doses of N showed dark green colour. Days to maturity were increased with increasing N up to 150 kg N/ha ranging from 75.33 to 82.33 days. And then it was decreased to 81.07 days at 180 kg N/ha. Incorporation of 150 kg N/ha produced the highest bulb yield (22.15 t/ha) closely followed by 180 kg N/ha (21.08 t/ha), 120 kg N/ha (20.74 t/ha) and 90 kg N/ha (17.32 t/ha). Plants with 120 kg N/ha gave 16.43% split bulb which was statistically similar to the 90 kg N/ha (14.96%) and 150 kg N/ha (18.22%). Incidence of bolting gradually decreased with the increase in N rates. In the economic point of view, the highest gross return (Tk. 890295), net return (Tk. 624968) and benefit-cost ratio (3.36) were observed at 150 kg N/ha. It is concluded that 150 kg N/ha was optimum for the production of onion (var. BARI Piaz-4) through set to bulb method.

Keywords: Onion, *Allium cepa*, Nitrogen, Set to Bulb Method, Yield and Quality.

Introduction

Onion (*Allium cepa* L.) is a member of the family Alliaceae grown throughout the world including Bangladesh. It is one of the most important spice crops popularly known as ‘piaz’ in Bangladesh. Among the spice crops, onion ranks first in Bangladesh based on the daily intake (35 g/day/person) and production as well. The total area for onion production in the country is about 2.04 lakh hectare, which produces about 25.47 lakh metric tons per annum and the average yield is very low, being 12.51 t/ha (Anon.,2024) as compared to Indian onion yield, being 16.80

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t/ha. The production of the country does not fulfill country's demand and to fulfill this demand, the government of Bangladesh imports around 9 lakh metric tons onions and shallots per year by expending hard earned foreign currency about 4 lakh crore Tk (Anon., 2024). Farmers in Bangladesh grow their onion following three methods: a) transplanting of seedlings, b) direct seeding in line or broadcast and c) through set to bulb method. Around 25-30% of total annual onions are produced through set to bulb method. In many countries, onions are largely grown through set to bulb method (Khokhar *et al*., 2002). The sets (small bulbs) are produced in previous season by seeding thickly @ 4-6 g seeds/m^2. The crops grown by set to bulb method can come into the market quite early in the season and meets market demand for several months. However, early harvesting during the season compensates for the additional price cost required for sets by high price received for the crops. The bulbs produced in this method are entirely fresh (green onion) and these bulbs are immediately consumed but not suitable for store purpose. Onion production is greatly influenced by different factors including cultural practices. Among the cultural practices, fertilizer especially nitrogen (N) plays an important role for producing onion. Islam *et al*. (1999) observed that the growth, yield and quality of onion produced through set to bulb method were greatly influenced by N doses. Both insufficient and excessive addition of N reduce yield and quality of onion. In Bangladesh, farmers grow their onion through set to bulb method by using different doses of nitrogen according to their willingness. Several studies have done with nitrogen on the growth, yield, quality of transplanting onion (Nasreen *et al*., 2007), but so far, research work on nitrogen doses for onion production through set to bulb method in the country is scanty. Therefore, it is very essential to determine optimum N dose for higher bulb yield of onion. The aforesaid reasons deserve the study on nitrogen fertilization for growing onion in set to bulb method. The present experiment was, therefore, undertaken to find out the optimum dose of nitrogen for higher yield and quality of onion (var. BARI Piaz-4) through set to bulb method.

Materials and Methods

The experiment was conducted at the Spices Research Sub-Centre (SRSC), Bangladesh Agricultural Research Institute (BARI) Faridpur during *rabi* season of 2023-2024 from October to January to find out the optimum N dose for higher yield and quality of onion (var. BARI Piaz-4) through set to bulb method. The experiment consisted of seven levels of nitrogen doses viz. T_2: 0 kg N/ha, T_2: 30 kg N/ha, T_3: 60 kg N/ha, T_4: 90 kg N/ha, T_5: 120 kg N/ha, T_6: 150 kg N/ha and T_7: 180 kg N/ha. A 3.5-6.5g size of disease free and healthy individual onion sets was used in the study. These sets were produced at Spice Research Sub Centre (SRSC), Bangladesh Agricultural Research Institute (BARI), Faridpur in previous season (2021-2022) by seeding thickly @ 4-6 g/m^2 in well prepared land like nursery bed. The field trial was laid out in randomized complete block design (RCBD) with three replications. The produced onion sets were planted in raised bed on 23 October 2023 with the spacing of 15 cm x 10 cm. Bulbs were placed keeping upright at a depth of 2.5 cm. Sets were also planted at the border of the experiment field separately for reuse when required. Rotten bulbs of the experimental plots were replaced by healthy ones from the border within 7 days of planting. The unit plot size was 2.00 m x 1.50 m having 200 plants. The experimental site belongs to Agro Ecological Zone-12 (Low Ganges River Floodplain). Soil samples were randomly collected at 0-30 cm soil depth for physical and chemical analysis before the commencement of the experiment. The physico-chemical properties of the field experimental plot are summarized in the Table 1. The soil was texturally clay loam and alkaline in reaction with the pH of 8.10. The presence of organic matter content in the trial field soil was very low (1.43%) against optimum requirement of 5%, as described by Khan (2018). The total available N content in the experimental soils was 0.08% which was within the range of low. The other nutrients, namely P, K, S, B and Zn were above the critical level. Rice (var. BRRI dhan57) was grown in the field before the experiment conducted. The experimental field was fertilized with 3000 kg well-decomposed cow dung, 0-180 kg N (as per treatment), 50 kg P, 85 kg K and 40 kg S per hectare. Cow dung was applied before ploughing the land. The entire quantity of triple super phosphate (TSP) for P, muriate of potash (MOP) for K, gypsum for S and one third of urea for N were applied as basal dose during final land preparation. The remaining urea was incorporated as top dress in two equal splits at 25 and 45 days after set planting. Two irrigations were applied in the field. First and second irrigation were done on 14 November 2023 and on 03 December 03, 2023, respectively. Preventing measure was taken by spraying Rovral 50 WP (500 g iprodione/kg Rovral) @ 3 g/litre of water at 35 days after planting (DAP) to keep the crops free from diseases. Second spraying was done with Nativo 75 WG (trifloxystrobin 25% and tebuconazole 50%) @ 0.6 g/litre of water at 45 DAP. Third spraying was done with Rovral at 55 DAP using the above rate to keep the diseases under control. Last spraying was done with Nativo using the above rate at 65 DAP. Bulbs were harvested at maturity when the pseudostem of non-bolted plants becomes flaccid and unable to support the leaf blades. Under the study harvesting of bulb was done at different dates according treatments. The leaves of harvested onion were removed by cutting 2.0-2.5 cm above the bulb. Ten plants were randomly selected from each plot for recoding data and averaging it. Flower stalks were taken on 29 December 2023, 02 January 2024 and 06 January 2024 from each treatment. Data was recorded on plant height (cm), number of leaves per plant (no.), percent bolting (%), yellowing of leaves (%), maturity of bulbs (days), polar and equatorial diameter of bulb (cm), individual bulb weight (g), multiplier (split) bulbs (%), dry matter content of bulbs (%), total soluble solid content (°brix or %), weight of flower stalks per plot (g) and days to maturity. Flower stalk weight per plot and bulb weight per plot were converted to per hectare yield as kg/ha and t/ha, respectively. Plant height and number of leaves were recorded at harvest. The number of bolting plants (undesirable flowering stalk) was visually counted in each plot, recorded and expressed in percent in relation to the total number of plants. The yellowing severity of leaf caused by nitrogen deficiency was scored by following 0-5 scale. The details of scales are as follows:

0-no yellowing symptoms, 1- yellowing covering 10% leaf area, 2- yellowing covering 20% leaf area, 3- yellowing covering 40% leaf area, 4- yellowing covering 75% leaf area and 5- complete yellowing of the leaves. Observations were made at the first appearance of yellowing symptoms on leaves, till the harvest at weekly intervals. The yellowing severity of leaf was presented with bar graph. The number of multiplier (split) bulbs was visually counted in each plot, recorded and expressed in percent in relation to the total number of bulbs per plot. The percent dry matter content of bulbs was calculated by dry weight basis as per procedure of Walle *et al*. (2018). Percentage data of bolting, split bulb, single bulb and dry matter of bulb were converted into Arcsine transformation values. The Arcsine transformation values were shown in parenthesis. The total soluble solid (TSS) content of bulbs was recorded by hand held refractometer (ATAGO, Master-53M, Japan) with a range of 0-53 °brix. The recorded data were analyzed with the help of Statistical Software 'R' and the means were compared by the least significant difference (LSD) test.

Profitability analysis was done. Based on the market price of all the applied inputs and wholesale price of the produce; cost, return and benefit ratio (BCR) were calculated.

Table 1. Physico-chemical properties of initial soil at the experimental plot of SRSC, BARI, Faridpur in 2021-2022

Soil texture	Soil pH	OM (%)	K	Ca	Mg	Total N (%)	P	S	B	Zn	Fe	Cu	Mn
			meq/100 g				µg/g soil						
Clay loam	8.10	1.43	0.57	27.96	4.3	0.08	21.7	18.6	0.67	2.76	33.92	0.53	11.9
Critical level			0.12	2.0	0.5	0.15	7.0	10.0	0.2	0.6	4.0	0.2	1.0

Results and Discussion

Plant height

Plant height was significantly influenced by various nitrogen (N) doses (Table 2). Plant height was increased with the increase of nitrogen doses up to 150 kg/ha and then it was decreased. The tallest plant was recorded at 150 kg N/ha (43.93 cm) closely followed by 120 kg N/ha (42.85 cm). Growing onion through set to bulb method without N gave the shortest plant (30.92 cm). Nitrogen application @ 180 kg/ha produced 43.80 cm tall plant height. The shortest plant height from without nitrogen might be due to growing onion under deficient of N in the soil (Table 1). Rice *et al*. (1990) recorded stunted onion plant with a lower level of N in soil. The increase in plant height with the addition of higher N fertilizer could be due to the increased availability of N for vegetative growth because of protein synthesis and the accumulation of carbohydrates. This finding agrees with the result of Tiffin and Boxworth (2005) who disclosed that onion plants that were deficient in nitrogen had stunted growth depending on the severity of the deficiency. The lowest plant height from zero kg N/ha or lower dose of N might be due to N deficiency, which limits chloroplast development, chlorophyll concentration and enzyme activity (Soleymani and Shahrajabian, 2012). Islam *et al*. (1999) registered increasing plant height with the increase in N rates (0, 60, 120 & 180 kg N/ha) in set to bulb method. On the other hand, Nasreen *et al*. (2007) reported that plant height increased with the increase in N rates (0, 80, 120 & 160 kg N/ha) up to 120 kg N/ha and then it was tended to decrease with further increase in N rates in transplanting onion. The decreasing plant height from 180 kg N/ha might be due to over dose of nitrogen. Excessive use of N fertilizers is a concern, since large amounts of N can remain in the soil after crop harvest (Fageria and Baligar, 2005). They also stated that usually 50% of N applied is effectively used by plants. Excess nitrogen increases plant height.

Table 2. Effects of nitrogen regimes on plant height, number of leaves/plants, incidence of bolting, equatorial and polar diameter of onion in set bulb method

Nitrogen rate (kg/ha)	Plant height (cm)	Number of leaves/plant	Bolting (%)	Bulb equatorial diameter (cm)	Bulb polar diameter (cm)
0	30.92	3.87	8.17 (16.61)	2.95	3.86
30	36.19	3.99	12.67 (20.85)	3.76	4.57
60	38.94	4.52	12.17 (20.42)	3.97	4.86
90	41.71	4.73	11.33 (19.67)	4.27	5.72
120	42.85	4.89	10.83 (19.21)	4.51	5.99
150	43.93	5.65	10.59 (18.99)	4.79	6.10
180	41.80	5.33	9.83 (18.27)	4.53	5.91
CV%	7.85	8.16	11.93	9.78	10.48
LSD (0.05)	4.265	0.716	3.516	0.694	1.173
Level of sig.	**	*	*	**	**

Foot note: ** Significant at the 1% level of significance and * Significant at the 5% level of significance. +Arcsine transformed values were shown in the parenthesis.

Number of leaves per plant

Number of leaves per plant was significantly influenced by various N doses (Table 1). The maximum number of leaves per plant was observed at 150 kg N/ha (5.65) closely followed by 120 kg N/ha (4.89), 90 kg N/ha (4.73) but significantly followed by 60 kg N/ha (4.52). However, the lowest number of leaves per plant was noted with nourishing onion field @ zero (0) kg N/ha (3.87). The lowest number of leaves per plant from zero kg N/ha or lower dose of N might be due to N deficiency, which limits chloroplast development, chlorophyll concentration and enzyme activity (Soleymani and Shahrajabian, 2012). At the maximum dose @ 180 kg N/ha, number of leaves per plant tended to reduce. Increased leave number per plants with increase in the rate of N dose might be due to reasons mentioned above in the case of plant height. The current result was supported by the earlier findings of Dinega *et al*. (2023), who observed that increasing N from 50 to 150 kg/ha increased leaf number. Beyond 150 kg/ha, the number of leaves decreased. Islam *et al*. (1999) depicted that number of leaves/plants increased with the increase in N rates (0, 60, 120 & 180 kg/ha) in set to bulb method, while, in transplanting method Nasreen *et al*. (2007) recorded gradual increase in number of leaves per plant with the increase in N rates (0, 80, 120 & 160 kg N/ha) up to 120 kg N/ha and then it was tended to decline with further increase in N rates.

Bolting percentage

The first highest and second highest percentage of bolting were observed from the application of 30 and 60 kg N/ha (12.67%, 12.17%), respectively, beyond which it was gradually and insignificantly decreased with the increase in N rates. Plants receiving zero (0) kg N/ha produced the lowest bolting percentage (8.17%). When onion plants experienced a mild nutrient stress, such as reduced nitrogen, they may accelerate their reproductive cycle. This stress responsible causes the plant to shift from vegetative to reproductive growth as a survival mechanism, leading to more abundant flowering. Hence, nitrogen deficient onion plants with 30-60 kg N/ha resultant in more flowers. Low C/N ratio (@ higher N ratesfavours vegetative growth and high C/N ratio (@ lower N rates favours reproductive growth in horticultural plants. They further stated that bulb N content increased with increasing N fertilizer and bolting decreased steadily with increasing bulb and shoot N contents. The present result is in agreement with the findings of Geisseler *et al*. (2022) and Abdissa *et al*. (2011) who stated that increasing N availability generally decreased incidence of bolting. On the other hand, onion plants without receiving nitrogen would be unable to carry out efficient photosynthesis, leading to reduced energy production and stunted growth, which would hinder both vegetative and reproductive development.

Diameter of bulb

The equatorial diameter of bulb was increased with the increase of N doses up to 150 kg N/ha ranging from 2.95 to 4.79 cm, beyond which the equatorial diameter was decreased (4.53 cm) and the lowest from control (3.86 cm). The similar results were also found for polar diameter of bulb. Application of N @ 150 kg/ha gave the maximum polar diameter (6.10 cm) closely followed by 90 kg N/ha (5.72 cm), 120 kg N/ha (5.99 cm) and 180 kg N/ha (5.91 cm). While the minimum polar diameter of bulb (3.86 cm) was recorded when no nitrogen was applied. Polar and equatorial diameter of bulbs were increased by 43.66% with the increase in N rate from 50 to 150 kg/ha (Dinega *et al*., 2023). They further stated that increasing the N rate beyond 150 kg/ha did not increase bulb diameter. Dinega *et al*. (2023) reported that development of wider bulbs with increasing rate of N fertilizer up to 150 kg/ha could be associated with the availability of more growth resources due to efficient N use as bulbs develop. On the other hand, lower bulb growth beyond

150 kg/ha could be due to excessive growth of above-ground biomass resulting from the application of excess N. In set to bulb method Islam *et al*. (1999) revealed that both polar and equatorial diameter of bulb were increased with the increase of N dose (0, 60, 120 & 180 kg N/ha) up to 120 kg/ha and then it was decreased with 180 kg N/ha. Nevertheless, in transplanting onion Nasreen *et al*. (2007) found increasing equatorial diameter with the increase in N rates (0, 80, 120 & 160 kg N/ha) up to 120 kg N/ha and the diameter was decreased at higher N rates. The reduced bulb growth due to application of excess N was also reported by Aregay *et al*. (2009) and Abdissa *et al*. (2011).

Individual bulb weight

Nitrogen application had significant effect on individual bulb weight (Table 3). Plants receiving no nitrogen produced the lowest weight of individual bulb (17.32 g). After that it was increased with the increase in the N doses up to 150 kg N/ha (34.22 g) and then it was decreased at 180 kg N/ha. Application of 150 kg N/ha produced the highest individual bulb weight which was identical with 90 kg N/ha (28.83 g), 120 kg N/ha (32.75 g) and 180 kg N/ha (33.94 g). Dinega *et al*. (2023) stated that the increase in fresh bulb weight with an increase in N fertilizer rate might be due to a sufficient supply of N that enhances chloroplast development resulting in chlorophyll synthesis, and enzyme activity that increased photosynthates. The present result is consistent with the findings of Dinega *et al*. (2023) who found decreased bulb weight with the over dose of 180 kg N/ha. Islam *et al*. (1999) found gradual increase in bulb weight from 0 to 120 kg/ha N and then it was declined at 180 kg N/ha. Nasreen *et al*. (2007) opined that individual bulb weight increased with the increased in N rates (0, 80, 120 & 160 kg N/ha) and thereafter it was decreased with further increase in N rates. Khan *et al*. (2021) found the maximum bulb weight at 180 kg N/ha in set to bulb method.

Table 3. Effects of nitrogen regimes on individual bulb weight, yield of bulb and flower stalk onion in set to bulb method

Nitrogen rates (Kg/ha)	Individual bulb weight (g)	Bulb yield/plot (3.0 m^2) (kg)	Yield of bulbs (t/ha)	Yield of flower stalks (kg/ha)
0	17.32	3.02	10.05	514.20
30	22.93	3.68	12.27	1186.23
60	26.86	4.77	15.90	1109.60
90	28.83	5.20	17.32	984.70
120	32.75	6.22	20.74	903.72
150	34.22	6.65	22.15	859.13
180	33.94	5.90	21.08	778.83
CV%	10.28	9.52	19.68	21.86
LSD (0.05)	5.457	0.697	3.402	89.916
Level of sig.	**	**	**	**

Foot note: ** Significant at the 1% level of significance

Bulb yield per plot

Application of N had significantly changed the bulb yield/plot (Table 3). The highest bulb yield/plot was recorded at 150 N kg/ha (6.65 kg) closely followed by 120 kg N/ha N (6.22 kg). The lowest bulb yield/plot was observed at zero kg N/ha (3.02 kg).

Yield of bulbs

An increase in bulb yield was observed at the increased doses of N up to 150 kg N/ha and then the bulb yield was decreased. The maximum bulb yield was obtained at 150 kg N/ha (22.15 t/ha), which was statistically similar to 180 kg N/ha (21.08 t/ha), 120 kg N/ha (20.15 t/ha) but statistically dissimilar to 90 kg N/ha (17.32 t/ha). However, fertilizing the onion field with zero (0) kg N/ha gave the lowest yield of bulbs (10.05 t/ha). The current finding is in agreement with the results of Dinega *et al*. (2023), who stated that the bulb yield increased in response to increasing N rates up to 150 kg/ha and the over dose beyond 150 kg/ha declined the bulb yields. They further opined that the increased bulb yield in response to 150 kg/ha might be due to plants receiving sufficient N. Geisseler *et al*. (2022) reported that enhanced leaf number and length may lead to increased photo-assimilate production resulting in increased bulb yield. Mahdieh *et al*. (2012) depicted that the decrease in total bulb yield with application of N beyond 150 kg/ha might be due to luxury consumption of N that affected onion plant metabolism by decreasing the ability of the root surface to absorb phosphorus and decreasing the assimilate preparation. Islam *et al*. (1999) obtained a gradual increase of yield through set to bulb method from 0-120 kg N/ha and then the yield was decreased at 180 kg N/ha. Dhital *et al*. (2017) also found the highest yield from 120 kg N/ha and further increase in N rates decreased yield. In set to bulb method Khan *et al*. (2021) obtained the highest yield from 180 kg N/ha among five rates of N (0, 60, 120, 180 and 240 kg N/ha). Working with transplanting onion Nasreen *et al*. (2007) stated that increasing N levels from 0 to 120 kg/ha resulted in progressive increase in bulb yield and further increase in N (160 kg/ha) tended to depress bulb yield. The highest bulb yield of onion was observed at 150 kg N/ha and the lowest from 50 kg and 100 kg N/ha through set to bulb method (Biesiada and Kolota, 2009).

Yield of flower stalks

The highest yield of flower stalks was found from the incorporation of N at 30 kg N/ha (1186.23 kg/ha) closely followed by 60 kg N/ha (1109.60 kg/ha). But the highest yield was significantly followed by the values of other treatments. However, the lowest yield of flower stalks was noted in the treatment of zero (0) kg N/ha (514.20 kg/ha). The highest yield of flower stalks at 30 kg N/ha might be happened due to maximum incidence of bolting in this treatment.

Yellowing of leaves

The extent of variation was more pronounced in the yellowing of onion leaves among the nitrogen regimes (Fig.1 1). Growing onion in set to bulb method without N exhibited yellowing in colour on the plants under the score 5 (100% of leaves) significantly followed by 30 kg N/ha (score 3: 40% of leaves). On the other hand, onion plants receiving N @ 60-180 kg/ha had no sign of yellowing on the plant. Instead of yellowing, plants with receiving higher doses of N showed dark green in colour. Probable cause of yellowing in growing onion without nitrogen might be due to the deficient of nitrogen. This result is in line with the findings of Geisseler *et al*. (2022) who narrated that increasing N rate is associated with promoting above-ground vegetative growth and the synthesis of chlorophyll, resulting in dark green leaves. The total N content in the experimental soils was 0.08%, which is far below than critical level (Table 1). The total N content of the soil under present experiment was within the range of low. According to Havlin *et al*. (2021), soil total available N contents of less than 0.15, 0.15-0.25 and >0.25% are categorized as low, medium and high, respectively. The present result is in consonance with the finding of Tiffin and Boxworth (2005), who stated that onion plants that are deficient in nitrogen exhibits yellowing in colour.

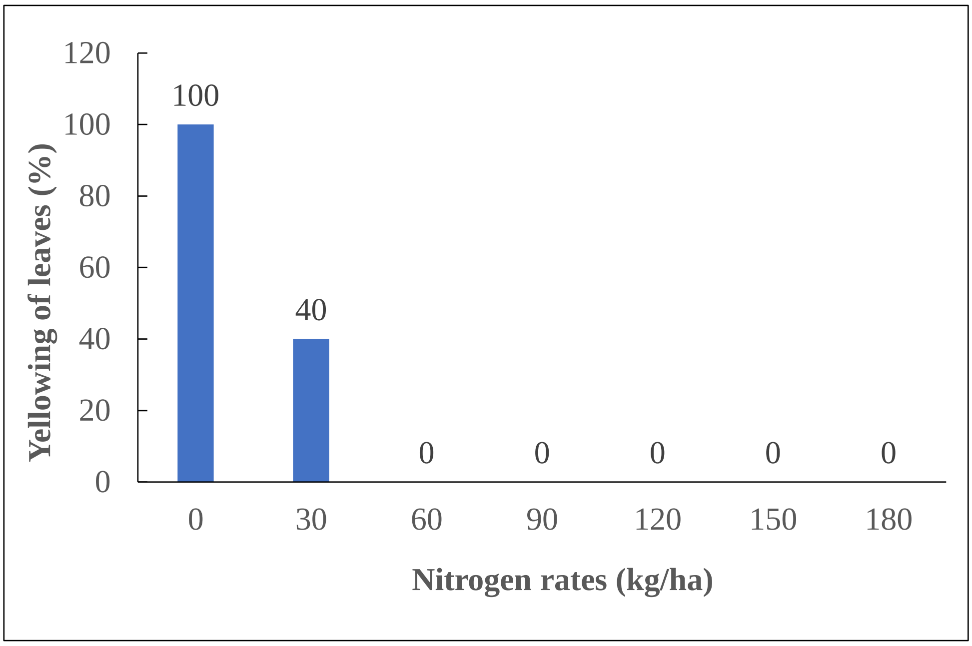

Fig. 1. Incidence of yellowing (%) on onion leaves according to nitrogen rates.

Maturity of bulbs

Days to maturity were increased with the increased N up to 150 kg N/ha ranging from 75.33 to 82.33 days. And then it was decreased to 81.07 days at 180 kg N/ha.

Plants grown at 150 kg and 120 kg N/ha got matured 7.0 and 5.67 days later than that of no N fertilization, respectively. Delayed maturity with receiving higher doses of N might be due to excessive vegetative growth. The present result supports the findings of Abdissa *et al*. (2011) who reported that N fertilization significantly extended 5 days of physiological maturity at 115-138 kg N/ha over the unfertilized treatment. Islam *et al*. (1999) reported that the highest dose of N (0, 60, 120 & 180 kg N/ha) prolonged the growing period in set to bulb method. On the contrary, Dhital *et al.* (2017) described that onion matured about 7 days earlier at 120 kg N/ha than those grown with no N fertilizer and further increase in N had no significant effect on maturity.

Table 4. Effects of nitrogen regimes on maturity of bulbs, percent of split & single bulb, bulb dry matter and total soluble solid of onion in set to bulb method

Nitrogen rates (kg/ha)	Maturity of bulbs (Days)	Split bulbs (%)	Single bulb (%)	Bulb dry matter (%)	Total soluble solid (°brix)
0	75.33	10.63 (19.03)	89.37 (70.97)	15.65 (23.30)	17.11
30	76.67	12.40 (20.62)	87.60 (69.38)	16.40 (23.89)	17.55
60	77.67	14.47 (22.36)	85.53 (67.64)	17.09 (24.42)	17.78
90	79.00	14.96 (22.75)	85.04 (67.25)	17.43 (24.68)	17.99
120	81.00	16.43 (23.91)	83.57 (66.09)	17.69 (24.87)	18.11
150	82.33	18.22 (25.27)	81.78 (64.73)	17.93 (25.05)	18.44
180	81.67	19.82 (26.44)	80.18 (63.56)	16.75 (24.16)	17.77
CV%	10.56	15.83	4.87	7.77	6.95
LSD (0.05)	2.635	2.052	3.164	1.751	1.406
Level of sig.	*	**	**	*	NS

** Significant at the 1% level of significance ,* Significant at the 5% level of significance and NS=Not significant; Arcsine transformed values were shown in the parenthesis.

Splitting of bulbs

A considerable variation in the split bulb (%) was caused by the levels of N (Table 4). The percent split bulb increased with the increasing levels of N. A dose of 180 kg N/ha produced the highest percent of split bulbs (19.82%), whilst the lowest split bulbs (10.63%) was registered from the control (0 kg N/ha). The present result corroborates the finding of Islam *et al*. (1999) who stated that maximum split bulb percent was recorded from higher rates of N (0, 60, 120 & 180 kg/ha) through set to bulb method. They further explained as higher N enhanced vegetative growth along with much tittering that resulted in a greater number of splitted bulbs. Among three rates of N (0, 40, 80, 120 & 160 kg N/ha), incidence of doubles was significantly increased by nitrogen application (Dhital *et al*., 2017). Growing onion in set to bulb method Khan *et al*. (2021) also recorded the maximum split bulbs (%) at 180 kg N/ha among five doses of N (0, 60, 120, 180 & 240 kg/ha).

Single bulbs

The single bulbs percent was significantly influenced by N fertilization (Table 4). The percentage of single bulb was decreased with the increase of N dose ranging from 89.37% to 80.18%. Higher percent of single bulb from zero kg N/ha or lower dose of N/ha might be due to lower incidence of split bulbs. The present finding corroborates the result of Islam *et al*. (1999) who opined that the application of higher N doses (0, 60, 120 & 180 kg/ha) caused the gradually increase of single bulb in set to bulb method.

Dry matter content of bulbs

The bulb dry matter content gradually increased with the increase in N up to 150 kg N/ha and varied from 15.65 to 17.93% (Table 4). After that it was decreased to 16.75% at 180 kg N/ha. The increased bulb dry weight from 150 kg/ha might be due to enough N supply for photosynthesis and photo-assimilate production (Geisseler *et al*., 2022). Nevertheless, Aregay *et al*. (2009) and Abdissa *et al*. (2011) found the lower bulb dry weight at over doses (from 200 to 250 kg N /ha) which might be because of excessive growth of above-ground biomass and low bulb growth performance resulting from the application of excess N. Islam *et al*. (1999) stated that dry matter of bulbs increased with the increase in N rates up to 120 kg N/ha and then it was decreased with further increase of N at 180kg N/ha in set to bulb method. Dhital *et al*. (2017) also reported that dry matter of bulb increased with the increase in N rates up to 120 kg N/ha and thereafter it was decreased at 160 kg N/ha. However, the maximum percent of bulb dry matter was recorded from addition of 100 kg N/ha and the minimum from 50 kg and 150 kg N/ha in growing onion from sets (Biesiada and Kolota, 2009).

Total soluble solid content:

Total soluble solid content (TSS) was not significantly influenced by N fertilization (Table 4). The results of TSS were in the similar direction to those of bulb dry matter content. However, the maximum TSS content was recorded at 150 kg N/ha (18.44°brix) and the lowest TSS content was observed at zero (0) kg N/ha (17.11°brix). The possible reason for increasing total soluble solids with a higher application rate of N might be due to increased chlorophyll content and dry weight plant. The result is in conformity with those of Dinega *et al*. (2023) who noted that the TSS content increased with increasing N rates.

Profitability analysis

The profitability analysis showed (Table 5) that application of 180 kg N/ha had the highest cost of production (Tk. 267060) and the lowest at zero kg N/ha (Tk. 256660). Highest cost of production was due to maximum use of N fertilizers. Maximum gross return (Tk. 890295), net return (Tk. 624968) and benefit-cost ratio (BCR, 3.36) were calculated at 150 kg N/ha as compared to other treatments.

Applying zero kg N/ha gave the lowest gross return (Tk. 404571), net return (Tk. 147911) and BCR (1.58). The highest gross return, net return and BCR at 150 kg N/ha might be due to obtaining maximum yield from this treatment.

Table 5. Profitability analysis of onion production through set to bulb method as per N rates (Tk./ha)

Nitrogen rates (kg/ha)	Yield (kg/ha)		Cost of production (A)	Gross returns (B)	Net returns (B-A)	BCR (B/A)
	Bulb	Flower stalks				
0	10050	514.20	256660	404571	147911	1.58
30	12270	1186.23	258393	496731	238338	1.92
60	15900	1109.60	260126	641548	381422	2.47
90	17320	984.70	261860	697723	435863	2.66
120	20740	903.72	263593	834118	570525	3.16
150	22150	859.13	265327	890295	624968	3.36
180	21080	778.83	267060	847094	580034	3.17

Wholesale price of onion bulbs and flower stalks 40 and 5 Tk./kg, respectively

Conclusion

Based on the result of the present study, in the economic point of view it might be concluded that application of 150 kg N/ha was optimum for onion production (var. BARI Piaz-4) through set to bulb method.

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