

Effect of Nitrogen and its Methods of Application on Growth and Yield in Potato

M. Raihanul Islam Chowdhury, ¹A.K.M. Golam Sarwar and A.M. Farooque

Department of Horticulture, ¹Department of Crop Botany,
Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

Abstract: To find out the effect of nitrogen and the proper method of its application for maximizing the yield of potato, four doses of nitrogen, 0, 60, 120 and 180 kg ha⁻¹, supplied as urea (containing 46% N), and five different methods of its application, were used. All top dressing operations were done in two installments of equal quantity at 30 and 50 days after planting (DAP) of potato tuber. All the parameters studied were differed significantly among the doses and methods of urea application. Application of urea @ 180 kg N ha⁻¹ as 50% basal + 50% top dressing produced the highest yield among the doses and methods, and it was found to be the most cost effective (1.99). It might be concluded that 180 kg N ha⁻¹ and split application (50% basal + 50% top dressing in two installment of 30 and 50 DAP) was superior to all other treatments to avoid the detrimental effect of urea on plant emergence, growth and tuber yield in Bangladesh.

Key words: Nitrogen, methods of application, growth, yield, potato

Introduction

Potato (*Solanum tuberosum* L.) occupies first position both in acreage and production among the vegetables crops in Bangladesh (Anonymous, 2001). However, the average yield of Bangladesh is quite low in comparison to the leading potato growing countries of the world (Anonymous, 2001). The poor fertilizer management i.e. improper use of manures and fertilizers is one of the reasons for such a poor yield (Islam *et al.*, 1982). Nitrogen plays a major role in the production and maintenance of an optimum plant canopy for continuing tuber growth through long growing period (Westermann and Kleinkopf, 1985). Available reports indicated that the yield of potato might be increased substantially through the judicious application of nitrogen along with other fertilizers (Annad and Krishnappa, 1989; Osaki *et al.*, 1992; Schonberger and Erichsen, 1994; Hossain *et al.*, 1995). Farmers of Bangladesh use urea as the main source of nitrogen for potato cultivation. Urea is an inferior source of nitrogen to potato due to its adverse effect on crop emergence (Sharma and Grewal, 1987). Split application of urea plays an important role to escape the detrimental effect on crop emergence and yield of potato (Sharma, 1990; Sud *et al.*, 1991; Sharma and Ezekiel, 1993; Joern and Vitosh, 1995). However, a little information on the methods of urea application under Bangladesh condition is available (Chowdhury *et al.*, 2002). Therefore, the present experiment was conducted to study the effect of nitrogen supplied as urea on growth and yield of potato and to find out the appropriate method of its application for maximizing the yield in Bangladesh.

Materials and Methods

The experiment was carried out at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period of November, 1996 to March, 1997. The experimental area was medium highland of sandy loam soils and belongs to the Sonatola series of Old Brahmaputra flood plain soil (Agro-Ecological Zone 9) (Anonymous, 1988). The physical and chemical properties of the soils of experimental plot were analyzed (Table 1) in the Humboldt Soil Testing Laboratory, Bangladesh Agricultural University, Mymensingh.

The experiment was laid out in a randomized complete block design (RCBD). Recommended doses of fertilizers except nitrogen were applied to each of the experimental plots (Anonymous, 1994). Whole amount of triple super phosphate, muriate of potash and gypsum was applied as basal dose through broadcasting during final land preparation. Four doses of nitrogen, N₀, N₆₀, N₁₂₀ and N₁₈₀ i.e. @ 0, 60, 120 and 180 kg N ha⁻¹, were supplied as urea (containing 46% N) and five different methods of its application (M) were as follows:

M₁: Application of total or 100% urea as basal dose

M₂: Application of 75% urea as basal dose + 25% as top dressing in two installments at 30 and 50 days after planting (DAP)

M₃: Application of 50% urea as basal dose + 50% as top dressing in two installments at 30 and 50 DAP

M₄: Application of 25% urea as basal dose + 75% as top dressing in two installments at 30 and 50 DAP and

M₅: Application of 100% urea as top dressing in two installments at 30 and 50 DAP.

Table 1: Soil analysis data of the experimental plot

Soil properties	Values
Physical properties:	
Sand (%)	35.4
Silt (%)	60.00
Clay (%)	4.6
Textural class	Silty loam
Chemical properties:	
pH	5.50
Organic C (%)	1.017
Total N (%)	0.085
Available P (ppm)	16
Available K	0.22 me of K/100 g of soil

The seed tubers of the variety diamant was collected from Bangladesh Agriculture Development Corporation and spreaded over the floor in diffused light conditions for sprouting. Well sprouted seed potatoes each of 25 g weight were used for planting. Planting was done in each plot of 2.4 × 2.0 m² maintaining spacing of 60 × 20 cm². Intercultural operations like weeding, earthing up, irrigation and effective plant protection measures were done as and when necessary. Data on ten randomly selected plants per plot were recorded during the crop growth period and also at harvest. The crops were harvested at 97 DAP. Data were recorded on days required to 80% emergence, plant height, foliage coverage (%) per hill, number of main stem per hill, fresh weight and dry weight of haulm, dry weight (%) of tuber, number of tuber per hill, yield of tuber per hill and yield of tuber per plot. The tuber yield per hectare was estimated and tubers were graded as A (> 55mm), B (> 45-55 mm), C (> 35-45 mm), D (> 28-35 mm) and E (< 28mm) according to their diameter. The collected data were analyzed statistically following the ANOVA technique by using MSTAT-C statistical computer package programme. The means were separated by Duncan's new multiple range test (DMRT). Cost and return analysis in detail was done according to the procedure of Alam *et al.* (1989).

Results and Discussion

Nitrogen and methods of its application showed significant variation in respect of days required to 80% emergence of sprout

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Table 2: Effect of nitrogen and its methods of application on the growth, yield and yield contributing characters of potato

Treatments	Days required to 80% emergence	Plant height (cm)	Foliage coverage per hill (%)	Number of main stem per hill	Fresh weight of haulm (g/hill)	Dry weight of haulm (g/hill)	Dry weight of tubers (%)	Number of tuber per hill	Weight of tubers per hill (g)	Yield of tubers per plot (kg)	Yield of tuber (t ha ⁻¹)
N ₀ M ₁ *	14.67	28.67	32.17	3.53	33.33	3.13	17.67	5.10	165.0	4.68	9.76
N ₀ M ₂	15.67	28.67	32.40	3.53	34.67	3.27	17.77	5.10	167.67	4.68	9.76
N ₀ M ₃	15.00	28.80	31.83	3.63	34.67	3.26	17.70	5.07	161.67	4.75	9.89
N ₀ M ₄	15.33	28.73	32.13	3.57	35.00	3.31	17.73	5.10	160.00	4.73	9.87
N ₀ M ₅	15.00	28.53	31.63	3.50	34.33	3.37	17.73	4.93	167.00	4.70	9.76
N ₆₀ M ₁	26.00	50.90	67.20	3.57	75.00	9.33	17.10	5.50	305.00	9.78	20.38
N ₆₀ M ₂	21.00	51.40	67.43	3.67	93.33	8.83	18.00	6.40	324.00	10.32	21.50
N ₆₀ M ₃	16.67	52.53	68.50	3.67	101.7	12.03	18.33	6.80	356.67	11.07	23.06
N ₆₀ M ₄	15.00	51.70	68.00	3.57	115.0	11.17	18.03	6.30	286.67	9.22	19.20
N ₆₀ M ₅	15.00	50.43	66.63	3.43	91.67	10.17	18.10	6.23	285.00	9.27	19.31
N ₁₂₀ M ₁	27.00	51.53	68.67	3.47	103.3	12.37	17.87	6.00	305.00	9.82	20.45
N ₁₂₀ M ₂	24.67	58.80	71.17	3.57	128.3	12.82	18.23	6.40	328.33	10.53	21.94
N ₁₂₀ M ₃	21.67	62.93	76.40	3.57	135.0	13.77	18.37	6.93	366.67	11.42	23.80
N ₁₂₀ M ₄	16.33	61.70	75.87	3.43	156.7	14.57	18.37	6.47	345.00	11.17	23.26
N ₁₂₀ M ₅	15.00	56.67	71.07	3.43	158.3	15.23	18.27	6.49	331.67	11.20	23.33
N ₁₈₀ M ₁	27.33	57.40	73.09	3.40	163.3	17.83	17.50	6.10	311.67	9.75	20.31
N ₁₈₀ M ₂	27.00	59.37	75.60	3.57	170.0	17.03	18.02	6.20	336.67	11.08	23.09
N ₁₈₀ M ₃	24.33	64.17	78.17	3.70	170.0	17.07	18.20	6.97	378.33	12.54	26.13
N ₁₈₀ M ₄	18.67	61.37	75.67	3.63	163.3	16.87	18.20	6.83	353.33	12.05	25.10
N ₁₈₀ M ₅	15.00	60.00	74.33	0.53	165.0	16.50	18.10	6.77	345.00	11.90	24.79
LSD at 0.05	1.89	2.16	2.16	0.15	5.23	2.78	0.36	0.43	8.75	0.37	4.33

Table 3: Effect of nitrogen and methods of its application on the percentage of different grade tubers of potato

Treatments	Grade A (> 55mm dia)	Grade B (> 45-55mm dia)	Grade C (> 35-45mm dia)	Grade D (> 28-35 mm dia)	Grade E (< 28mm dia)
N ₀ M ₁ *	17.50	15.33	18.25	26.83	22.09
N ₀ M ₂	17.42	15.41	18.56	26.63	22.18
N ₀ M ₃	17.50	15.13	19.00	26.20	21.90
N ₀ M ₄	17.60	15.21	18.22	26.67	22.22
N ₀ M ₅	17.45	15.46	18.24	26.91	21.49
N ₆₀ M ₁	18.86	16.77	18.44	29.44	16.49
N ₆₀ M ₂	18.82	20.03	19.88	27.35	18.06
N ₆₀ M ₃	20.07	19.23	21.77	25.07	13.19
N ₆₀ M ₄	17.82	18.29	21.65	29.19	12.72
N ₆₀ M ₅	20.23	16.13	21.05	26.09	16.51
N ₁₂₀ M ₁	21.10	20.58	23.38	25.66	14.14
N ₁₂₀ M ₂	25.38	22.78	22.71	17.43	11.70
N ₁₂₀ M ₃	26.45	22.44	23.12	17.17	10.82
N ₁₂₀ M ₄	28.81	23.91	21.83	16.20	9.26
N ₁₂₀ M ₅	28.72	21.58	20.23	17.94	11.54
N ₁₈₀ M ₁	33.17	26.14	21.06	12.41	7.22
N ₁₈₀ M ₂	32.23	27.06	21.24	11.57	8.04
N ₁₈₀ M ₃	32.78	26.30	19.20	14.06	7.66
N ₁₈₀ M ₄	32.63	25.47	21.64	15.03	10.27
N ₁₈₀ M ₅	28.17	24.06	19.60	15.55	12.61
LSD at 0.05	4.11	4.69	4.19	5.08	5.14

Table 4: Cost and return of potatoes as affected by nitrogen and its methods of application

Treatments	Yield (t ha ⁻¹)	Gross return * (Tk ha ⁻¹)	Total cost of production (Tk ha ⁻¹)	Net return (Tk ha ⁻¹)	Benefit cost ratio
N ₀ M ₁ *	9.76	48800.00	62684.8	-13884.80	-1.22
N ₀ M ₂	9.76	48800.00	62684.8	-13884.80	-1.22
N ₀ M ₃	9.89	49450.00	62684.8	-13234.80	-1.21
N ₀ M ₄	9.86	49300.00	62684.8	-13384.40	-1.21
N ₀ M ₅	9.76	48800.00	62684.8	-13884.80	-1.22
N ₆₀ M ₁	20.38	101900.00	63557.9	38342.1	1.60
N ₆₀ M ₂	21.50	107500.00	64057.9	43442.1	1.68
N ₆₀ M ₃	23.06	115300.00	64057.9	51242.1	1.80
N ₆₀ M ₄	19.20	96000.00	64057.9	31942.1	1.51
N ₆₀ M ₅	19.31	96550.00	63807.9	32742.1	1.50
N ₁₂₀ M ₁	20.45	102250.00	64429.8	37820.2	1.59
N ₁₂₀ M ₂	21.94	109700.00	64929.8	44770.2	1.70
N ₁₂₀ M ₃	23.80	119000.00	64929.8	54070.2	1.83
N ₁₂₀ M ₄	23.26	116300.00	64929.8	51370.2	1.79
N ₁₂₀ M ₅	23.33	116650.00	64679.8	51970.2	1.80
N ₁₈₀ M ₁	20.31	101550.00	65305.6	36244.4	1.55
N ₁₈₀ M ₂	23.00	115450.00	65805.6	49644.4	1.76
N ₁₈₀ M ₃	26.13	130650.00	65805.6	64844.4	1.99
N ₁₈₀ M ₄	25.10	125500.00	65805.6	59694.4	1.91
N ₁₈₀ M ₅	24.79	123950.00	65555.6	58394.4	1.89

*Numerical values in suffix indicated quantity of nitrogen in kg/hectare and M₁= 100% basal, M₂= 75% basal + 25% top dressing, M₃= 50% basal + 50% top dressing, M₄= 25% basal + 75% top dressing, M₅= 100% top dressing, **Calculated on the basis of Tk.5,000/ton of tuber

(Table 2). Treatment $N_{180}M_1$ took the longest time to complete 80% emergence (27.33 day after planting) and the shortest time (14.67 DAP) was required for treatment N_0M_1 . However, there were no significant differences among the treatments $N_{180}M_1$, $N_{180}M_2$, $N_{120}M_1$ and $N_{60}M_1$, and among all the treatments without nitrogen, $N_{60}M_3$, $N_{60}M_4$, $N_{60}M_5$, $N_{120}M_4$, $N_{120}M_5$ and $N_{180}M_5$. Similar insignificant results in different treatments were found in other characters studied under this experiment. Urea application required more time for emergence of sprouts. This delay in plant emergence might be due to the accumulation of free ammonia and nitrites in the soil after the incorporation of urea (Meisinger *et al.*, 1978). The adverse effect on plant emergence was more pronounced when whole amount of urea was applied as basal dose because the concentrations of free ammonia and nitrite was likely to be more near the seed tubers than those of the other methods of urea application. Split application of urea, however, reduced the adverse effect on plant emergence. Sharma (1990) also reported similar effect on the period of plant emergence.

The potato plant reached at the maximum height and foliage coverage per hill (64.17 cm and 78.17 % respectively) at treatment $N_{180}M_3$ and the minimum (28.53 cm and 31.63 % respectively) at treatment N_0M_1 (Table 2). This might be due to better availability of N and the enhancing effect of N on vegetative growth by increasing cell division and cell elongation. Methods of urea application played an important role in this regard. Since, the recovery of N from splitted dose remained higher than the whole dose of N applied at the time of planting (Sharma and Ezekiel, 1993).

The highest number of main stem per hill (3.70) was found at treatment $N_{180}M_3$ and the lowest (3.40) at $N_{180}M_1$ (Table 2). It was observed that the number of main stem per hill in the field was proportional to the number of sprouts on tuber at planting. This character mainly depends on the cultivar and physiological state of the seed tuber rather than the fertility of the soil (Annad and Krishnappa, 1989). The decrease in number of main stem might be due to the toxicity produced by the urea at the time of planting which ultimately killed the sprouts and the split application of urea reduced this toxicity.

The maximum fresh weight (170.0 g) of haulm was obtained at treatment $N_{180}M_2$ and $N_{180}M_3$, and the minimum (33.33 g) at N_0M_1 (Table 2). The higher plant height and greater main stem per hill due to efficient use of nitrogen increased the fresh weight of haulm. The present results were in full agreement with the report of Singh and Singh (1994). Dry weight of haulm was higher (17.83 g) at treatment $N_{180}M_1$ and lower (3.13 g) at N_0M_1 (Table 2). The increased dry matter accumulation in the haulm might be attributed to synthesis and translocation of photosynthates to the haulm and also due to availability of more nutrients from the soil (Annad and Krishnappa, 1989). Singh and Singh (1994) also observed that efficient use of higher nitrogen doses increased the dry weight of haulm per hill.

Treatment $N_{120}M_2$ and $N_{120}M_3$ produced the maximum dry weight of tuber (18.37% of fresh weight) while $N_{60}M_1$ produced the minimum dry weight (17.10%) (Table 2). The rate of dry matter production tended to decrease when whole amount of urea applied as basal dose, as the cells of tuber become succulent and possibly due to increased respiration loss as reported by Westermann and Kleinkopf (1985).

The highest number of tuber per hill (6.97) was found at treatment $N_{180}M_3$ and the lowest number (4.93) at N_0M_5 (Table 2). The increase in number of tuber per hill might be due to increased photosynthetic activity and translocation of photosynthates to the root which might helped in the initiation of more stolon in potato (Annad and Krishnappa, 1989).

The maximum weight of tuber per hill and yield of tuber per plot (378.33 g and 12.54 kg respectively) were found at treatment $N_{180}M_3$ and the minimum values (155.0 g and 4.68 kg respectively) at N_0M_1 (Table 2) which ultimately affected the tuber

yield per hectare. The increase in weight of tuber per hill might be possible as the nitrogen being the constituent of chlorophyll, promoted cell division and cell elongation, functional life of plants and production of carbohydrates (Singh and Sharma, 1987). Split application of urea nitrogen increased tuber yield, which might be due to the better availability of required amounts of nitrogen for optimum vegetative growth and tuber formation. The increased tuber yield might also be due to the improvement in plant emergence and early vegetative growth. Similar result was reported by Sud *et al.* (1991). The minimum yield was possibly due to the toxic effect exerted by urea from beneath the seed tubers placed in the furrow. This has also affected emergence, vegetative growth and other parameters studied in the experiment. As the tuber yield increased with the increasing amount of nitrogen up to 180 kg ha⁻¹, so there is a scope to test the effect of further increment of nitrogen on yield.

Effect of urea application was found to be significant in case of the production of potato of different grades (Table 3). The highest percentage of grade A, B, C, D and E tuber (33.17, 27.06, 23.38, 29.44 and 22.22 % respectively) was found at treatment $N_{180}M_1$, $N_{180}M_2$, $N_{120}M_1$, $N_{60}M_1$ and N_0M_4 , the lowest (17.42, 15.13, 18.22, 11.57 and 7.22 % respectively) at N_0M_2 , N_0M_3 , N_0M_4 , $N_{180}M_2$ and $N_{180}M_1$ respectively. Methods of urea application played a significant role in the production of potato of greater size (> 55 mm). This might be attributed to better growth and development of the plant and large tuber formation that were resulted due to better availability and efficient use of nitrogen by the plant. The other grades of potato tubers did not show any significant differences due to the methods of urea application. This confirms the findings of Sharma (1990). He also observed that small grade tuber yield is significantly higher under broadcast treatment.

All other treatments showed considerably higher net return over the treatment N_0M_3 (Table 4). The benefit cost ratio was also higher (1.99) at treatment $N_{180}M_3$. Similar results were reported by Chowdhury *et al.* (2002). They observed that the split application of urea as 50% basal and 50% top dressing in two installments at 30 and 50 DAP performed as the best method of urea application in Bangladesh. From the economic point of view it was apparent from the above result that the treatment $N_{180}M_3$ was more profitable than rest of the application methods.

It might be concluded that 180 kg nitrogen per hectare and split application (50% basal + 50% top dressing in two installment of 30 and 50 DAP) was superior to all other treatments to avoid the detrimental effect of urea on plant emergence, growth and tuber yield in Bangladesh.

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