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Effect of Eyes Number in Cut Seed Tuber and Different Levels of Nitrogen on Growth, Yield and Grading of Tuber Size in Potato (*Solanum tuberosum* L.)

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Abstract: Effect of different eyes number viz., E_1, E_2 and E_3 per cut seed tuber and five levels of nitrogen viz., N_0, N_{60}, N_{120}, N_{180} and N_{240} and their all possible combinations on the growth, yield and tuber size grading of potato (cv. Diamant) was studied at the Bangladesh Agricultural University during 1997 and 1998 cropping season. Canopy coverage, main stem number hill^{-1}, tuber number hill^{-1} significantly increased with the increasing number of eyes in cut seed tuber piece. Cut seed tuber piece with 3 eyes required the shortest period to shoot emergence, but produced the smallest tubers. Three eyed cut seed tuber produced the maximum tuber yield, 31.7 t ha^{-1}, which was statistically similar to 2-eyed seed piece (31.4 t ha^{-1}). Higher nitrogen significantly increased all the parameters studied and took less number of days to shoot emergence and tuber maturity. 240 KgN ha^{-1} produced the maximum tuber yield (35.2 t ha^{-1}), but the performance of N_{180} and N_{240} showed non-significant variation. Grade A (>55 mm) and B (55-40 mm) sized tubers increased, but grade C (40-28 mm) and D (<28 mm) sized tubers decreased with the increase of nitrogen. The highest tuber yield was obtained from the combination (s) of $E_2 \times N_{240}$ or $E_3 \times N_{180}$. Maximum tubers of grade A, B, C and D were produced from the combinations of $E_1/E_2 \times N_{240}$, $E_1 \times N_{60}/N_{240}$ or $E_2 \times N_{60}/N_{180}$ or $E_3 \times N_{60}$, $E_3 \times N_0$ and $E_2 \times N_0$, respectively. From the economic point of view, 2-eyed seed tuber piece and 180 KgN ha^{-1} were the best either singly or combinely to achieve maximum growth and yield potential.

Key words: Potato, seed tuber, eyes number, nitrogen levels, yield, tuber grading

Introduction

Potato is an important vegetable crop in Bangladesh and covers about 1,34,800 hectares of land having a production of 1,49,200 metric tons (Anonymous, 1997). Both area and production of potato crop in Bangladesh have increased during the last decade, but there is no significant yield increase per unit area. Potato yield and quality largely depend on the climatic and edaphic conditions as well as seed sources and nutrient inputs. Generally, potato is cultivated through tuber planting and eyes number in cut seed tuber influences potato yield (Smith, 1977; Entz and Lacroix, 1984 and Siddique *et al*., 1987). The cost of seed tuber is very high and occupies about 40% of the total production cost (Farooque *et al*., 1984). For this reason, the larger seed tubers are usually cut into pieces to get maximum number of seed, thus minimizing the seed cost. But it is not clear that how many eyes are to be kept in each cut tuber piece to obtain higher yield. Proper vegetative growth is needed for potato cultivation because more tubers are obtained from the plants of more vegetative growth and development. Like other crops, nitrogen induces rapid vigorous growth in potato through the enhancement of photosynthesis (Hossain *et al*., 1995). So, adequate supply of nitrogen is important to achieve this goal. Taking consideration the above facts, the present study was, therefore, carried out to investigate the influences of eyes number in cut seed tuber and different levels of nitrogen on the growth and tuber yield of potato.

Materials and Methods

The experiment on potato (cv. Diamant) was conducted at Bangladesh Agricultural University, Mymensingh, Bangladesh to investigate the effect of eyes number in cut seed tubers and different levels of nitrogen on the growth, yield and grading of tuber size. Potato crop was grown in 1997-98 winter cropping season and seed planting was done on 25 November 1997 in unit plot size of 3.6 X 1.2 m^2 maintaining a spacing of 60 X 20 cm^2. Cut seed tubers containing single eye (E_1: 10g piece^{-1}), 2 eyes (E_2: 15g piece^{-1}) and 3 eyes (E_3: 20g piece^{-1}) were used as eyes number treatments. Five different levels of nitrogen viz., 0 (N_0), 60 (N_{60}), 120 (N_{120}), 180 (N_{180}) and 240 (N_{240}) KgN ha^{-1} were applied as nitrogen treatments. All possible combinations of both treatments were also scheduled and the experiment was laid out in randomized complete block design (RCBD) with three replications. Manures and fertilizers except N were applied following standard measurements as non-limiting to plant growth. Urea fertilizer was applied as a source of N as per treatment schedule. Half of the total N was applied during the final land preparation and the rest half was side-dressed along the line after 30 days after seed planting. Weeding, irrigation, earthing–up, plant protections and other cultural practices were done with utmost care as and when required.

The data on days required for 80% shoot emergence, shoot height at maturity, canopy coverage (%) at 75 days after planting, number of main stems hill^{-1}, number of tubers hill^{-1}, weight of individual tuber (g), days to physiological tuber maturity, tuber yield (g hill^{-1} and t ha^{-1}) and tuber grading (grade A >55 mm; B =55-40 mm; C =40-28 mm and D< 28 mm in diameter) by number and weight bases were collected from the 10 randomly selected plants from each plot in such a way that the border effect was avoided for the highest precision. The collected data were analyzed statistically using MStat-C Computer Package Programme and the mean values were significantly differentiated from each other with DMRT.

Results and Discussion

Effects on the growth and tuber yield:

The single effect: Significant effects were found by eyes number in cut seed tuber on different growth traits and tuber yield of potato (Table 1). Seed pieces having 2 and 3 eyes required the shortest period (14.8 and 14.7 days, respectively) to produce sprout that emerged earlier than the seed pieces containing single eye (16.4 days). Cut seed tubers containing more eyes were larger in size with higher amount of reserved food materials and might have helped in early shoot emergence. Similar results were also reported by Kapoor (1951), Svensson (1972) and Smith (1977). Shoot height was not found to be affected by the eyes number in the cut seed

Table 1: Single effect of eyes number in cut seed tuber piece and different levels of nitrogen on growth and tuber yield of potato

Treatments	Days to shoot emergence	Shoot height (cm)	Canopy coverage (%)	No. of main stems hill^{-1}	No. of tubers hill^{-1}	Tuber weight (g tuber^{-1})	Days to tuber maturity	Tuber yield	
								g hill^{-1}	t ha^{-1}
Eyes number									
E_1	16.4 a	43.7	59.3 c	1.9 c	5.3 b	65.5 a	90.0	350.7 b	29.2 b
E_2	14.8 b	43.6	69.0 b	2.8 b	5.7 b	63.9 a	89.7	376.7 a	31.4 a
E_3	14.7 b	43.6	75.3 a	3.4 a	6.3 a	58.5 b	89.5	380.5 a	31.7 a
Signf level	0.01	ns	0.01	0.01	0.01	0.01	ns	0.01	0.01
N levels									
N_0	12.3 d	27.7 c	53.0 d	2.6 b	5.1 c	45.8 c	81.2 e	279.8 d	23.3 d
N_{60}	12.4 cd	36.5 b	60.0 c	2.5 b	5.7 b	59.0 b	84.8 d	329.4 c	27.5 c
N_{120}	13.0 c	42.0 b	66.1 c	2.8 a	5.9 ab	67.5 a	90.0 c	395.2 b	32.9 b
N_{180}	18.8 b	53.3 a	74.7 b	2.8 a	6.0 a	69.8 a	94.3 b	420.0 a	35.0 a
N_{240}	19.8 a	55.2 a	85.6 a	2.8 a	6.1 a	71.2 a	97.4 a	421.8 a	35.2 a
Signf level	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01

In a column figures bearing same letter (s) do no differ significantly at the respective level of probability. ns indicates non-significant.

Table 2: Combined effect of eyes number in cut seed tuber piece and different levels of nitrogen on the growth and tuber yield of potato

Treatment combinations (Eyes number X N levels)	Days to shoot emergence	Shoot height (cm)	Canopy coverage (%)	No. of main stems hill^{-1}	No. of tubers hill^{-1}	Tuber weight (g tuber^{-1})	Days to tuber maturity	Tuber yield	
								g hill^{-1}	t ha^{-1}
1-eyed seed									
N_0	13.3 d	27.7 c	47.3 g	1.6 de	4.9 e	50.6 cd	81.7 de	276.0 g	23.0 g
N_{60}	13.0 ef	36.3 c	53.3 fg	1.8 e	5.2 de	58.7 bc	85.3 d	305.0 f	25.4 f
N_{120}	14.4 d	45.4 bc	58.3 ef	2.1 c-e	5.4 c-e	70.5 ab	91.0 bc	373.3 d	31.1 d
N_{180}	19.7 b	53.8 a	64.0 de	1.8 de	5.5 a-e	72.0 ab	94.3 ab	401.7 c	33.5 c
N_{240}	21.3 a	55.5 a	73.3 c	2.0 e	5.4 b-e	75.8 a	97.7 a	398.7 c	33.2 c
2-eyed seed									
N_0	12.2 f	27.5 c	55.0 e-g	2.5 bc	5.1 de	47.7 cd	81.0 e	288.3 fg	24.0 fg
N_{60}	12.0 f	36.7 c	58.3 ef	2.4 b-d	5.5 a-e	61.7 a-c	85.0 d	333.3 e	27.8 e
N_{120}	12.3 ef	45.3 ab	71.7 cd	2.9 ab	5.8 a-e	70.2 ab	91.3 bc	403.3 c	33.6 c
N_{180}	18.3 c	53.3 a	75.0 c	3.0 ab	6.1 a-e	70.0 ab	94.1 a-c	423.3 ab	35.3 ab
N_{240}	19.3 bc	55.0 a	85.0 b	2.9 ab	6.2 a-d	70.1 ab	97.3 a	435.0 a	36.3 a
3-eyed seed									
N_0	12.0 f	27.3 c	56.7 ef	2.8 bc	5.4 c-e	39.2 d	81.0 e	275.0 g	22.9 g
N_{60}	12.0 f	36.6 c	63.3 de	3.4 a	6.4 a-c	56.5 bc	84.0 c	350.0 e	29.2 e
N_{120}	12.3 ef	45.3 ab	73.3 c	3.4 a	6.6 a	61.7 a-c	90.3 c	409.0 bc	34.1 bc
N_{180}	18.3 c	52.8 a	85.0 b	3.4 a	6.6 a	67.5 ab	94.7 ab	435.7 a	36.3 a
N_{240}	18.7 bc	55.3 a	98.3 a	3.6 a	6.7 a	67.4 ab	97.3 a	431.7 a	36.0 a

In a column figures bearing same letter (s) do no differ significantly at 5% level of probability.

Table 3: Single effect of eyes number in cut seed tuber piece and different levels of nitrogen on the grading of potato tuber

Treatments	Tuber size grading by diameter (mm)							
	Number of tuber (%)				Weight of tuber (%)			
	Grade A >55 mm	Grade B 55-40 mm	Grade C 40-28 mm	Grade D <28 mm	Grade A >55 mm	Grade B 55-40 mm	Grade C 40-28 mm	Grade D <28 mm
Eyes number								
E_1	7.3	32.1	38.5	22.1	17.9	43.4	33.7	5.0
E_2	7.1	29.8	39.0	24.1	17.3	44.0	33.8	4.9
E_3	5.3	27.1	42.1	25.5	13.7	41.3	39.4	5.6
Signf level	ns	ns	ns	ns	ns	ns	ns	ns
N levels								
N_0	4.0 b	17.3 b	52.2 a	26.5	10.8 c	32.2 b	51.4 a	5.6 a
N_{60}	4.9 ab	30.1 a	39.2 b	25.8	13.0 bc	42.1 a	41.5 b	3.4 c
N_{120}	8.0 a	30.2 a	41.7 b	20.1	18.4 ab	43.9 a	33.7 b	4.0 bc
N_{180}	8.1 a	32.5 a	38.4 b	21.0	18.9 a	45.2 a	31.2 b	4.7 a-c
N_{240}	8.7 a	33.1 a	35.9 b	22.3	20.9 a	44.0 a	30.5 b	4.6 bc
Signf level	0.01	0.01	0.01	ns	0.01	0.01	0.05	0.01

In a column figures bearing same letter (s) do no differ significantly at the respective level of probability. ns indicates non-significant.

tuber and Kapoor (1951) agreed with this statement. Canopy coverage, main stem number hill^{-1}, tuber number hill^{-1} and tuber yield significantly increased with increase in eyes number in cut seed tuber pieces. Cut seed tubers containing more eyes produced more stems hill^{-1} thus resulting greater canopy coverage and more number of tubers hill^{-1}, which in turn produced higher tuber yield. These findings were in conformity with those of Birecki and Roztropowics (1963), Cisneros and Herrera (1987), Escribano (1962), Chandara (1961) and Mahmood and Gill (1984). Individual tuber weight was found maximum (65.5 g) in single eyed cut seed piece, which was statistically identical with 2-eyed (63.9 g) and minimum (58.5 g) in the cut seed tubers containing 3 eyes. It might be due to the fact that seed piece having single eye produced less number of stems and tubers hill^{-1} resulting in increased individual tuber weight. Effect of seed piece's eye number on days to tuber maturity showed insignificant variation. However, the maximum time to harvest (90 days)

Table 4: Combined effect of eyes number in cut seed tuber piece and different levels of nitrogen on the grading of potato tuber

Treatment combinations (Eyes number X N levels)	Tuber size grading by diameter (mm)							
	Number of tuber (%)				Weight of tuber (%)			
	Grade A >55 mm	Grade B 55-40 mm	Grade C 40-28 mm	Grade D <28 mm	Grade A >55 mm	Grade B 55-40 mm	Grade C 40-28 mm	Grade D <28 mm
1-eyed seed								
N_0	5.6	17.1	52.1 ab	25.2	16.5 a-c	29.5 c	47.3 ab	6.7
N_{60}	5.8	29.7	36.4 cd	28.1	13.2 a-c	50.5 a	31.7 bc	4.6
N_{120}	8.1	28.3	44.1 b-d	19.5	18.4 a-c	43.0 a-c	34.2 bc	4.4
N_{180}	8.9	33.4	40.0 b-d	17.7	18.6 a-c	44.5 a-c	31.7 bc	5.2
N_{240}	9.6	38.2	31.9 d	20.3	22.8 a	48.6 a	24.4 c	4.2
2-eyed seed								
N_0	3.8	17.9	47.7 a-c	30.6	9.3 bc	31.9 bc	50.6 ab	8.2
N_{60}	4.0	30.4	41.7 b-d	23.9	13.8 a-c	50.6 a	33.3 bc	2.3
N_{120}	6.1	33.7	38.9 b-d	17.3	22.9 ab	45.3 ab	29.1 bc	2.7
N_{180}	10.1	38.3	33.0 cd	21.1	20.1 ab	50.6 a	24.9 c	4.4
N_{240}	9.9	29.3	34.8 cd	26.0	23.1 a	41.3 a-c	29.2 bc	6.4
3-eyed seed								
N_0	2.3	18.6	58.0 a	21.1	6.2 c	32.4 bc	56.3 a	5.1
N_{60}	4.7	29.8	40.5 b-d	25.0	13.4 a-c	54.8 a	29.8 bc	2.0
N_{120}	6.1	28.6	42.1 b-d	23.2	14.1 a-c	43.5 a-c	37.7 a-c	4.7
N_{180}	7.5	26.2	42.9 b-d	23.4	19.3 a-c	39.9 a-c	34.8 bc	6.0
N_{240}	6.5	31.7	41.3 b-d	20.5	15.6 a-c	40.7 a-c	38.4 a-c	5.3

In a column figures bearing same letter (s) do no differ significantly at 5% level of probability.

was observed under the single eye.

Significant variations were observed on the growth and yield of potato by different levels of nitrogen (Table 1). Shoot emergence was found to be gradually delayed with increasing nitrogen levels and N_{240} (240 KgN ha^{-1}) took the longest period (19.8 days) to complete 80% shoot emergence and N_0 exhibited the shortest period (12.4 days). This might be due to the fact that application of urea immediately before the tuber planting had discharged free ammonia and nitrate in the soil thus caused delay in shoot emergence. Sharma and Grewal (1978) reported that higher nitrogen levels adversely affected and delayed the tuber germination. Puskarnath and Patil (1959) observed the similar results. Shoot height showed a gradual increase with increasing levels of nitrogen. The tallest plants under the highest dose of N (I. e. N_{240}) was obtained due to the fact that plants received more nitrogen, which might have encouraged more vegetative growth. Singh and Sharma (1987) and Kushwah (1989) supported these findings. Increasing nitrogen levels were found to play a notable role to increase the canopy coverage that might have due to excessive above ground phytomass increments. This result is related to the findings of Dorobantu *et al.* (1989) and Tran & Siroux (1991). Stem number $hill^{-1}$, tuber number $hill^{-1}$, individual tuber weight and tuber yield were significantly maximum in N_{240} and minimum in N_0 and other N treatments showed successive trends. But the N_{180} and N_{240} treatments showed almost insignificant variations. Increasing nitrogen levels caused rapid vegetative growth and biomass synthesis thus producing greater number of shoots and stolons $hill^{-1}$, bigger sized tuber and higher yield. These results coincided with the findings of Dimistrov (1973), Bhowmik and Dandapat (1991), Møllerhagen (1993), Prosba and Bialczyk (1993), Juzl (1993) and Gagro *et al.* (1996). The tuber maturity period prolonged gradually with increasing nitrogen levels. It might be due to the perpetuating dark green canopy coverage under higher nitrogen, which caused delay in tuber maturity.

The combined effect: Different growth traits and tuber yield exhibited significant variations due to the combined effect of eyes number in cut seed tuber piece and different levels of nitrogen (Table 2). The highest time (21.3 days) required to shoot emergence was found in the combination of $E_1 \times N_{240}$ whereas the lowest time in $E_2 \times N_0/N_{60}$ and $E_3 \times N_0/N_{60}$. The tallest plants were produced from the combinations of N_{180} and N_{240} with all eyes numbered treatments. Maximum and minimum canopy coverage observed from the combinations of $E_3 \times N_{240}$ and $E_1 \times N_0$, respectively. The greater number of stems and tubers $hill^{-1}$ were obtained from E_3 along with N_{120}, N_{180} and N_{240}, and lesser from E_1 along with N_0 and N_{60}. The largest and smallest sized tubers were obtained from the combinations of $E_1 \times N_{240}$ and $E_3 \times N_0$, respectively. Maximum growing period required to tuber maturity was observed from the combinations of N_{240} with all eyes numbered treatments and minimum period from the combinations of N_{60} with E_1 and E_2 treatments. The best combinations for the highest tuber yield were $E_2 \times N_{240}$, $E_3 \times N_{180}/N_{240}$ whereas the lowest tuber yields were found from the $E_1/E_3 \times N_0$ combinations.

Effects on the tuber size grading:

The single effect: Tuber size grading by percentage in terms of number and weight as affected by the eyes number in cut seed tuber and different levels of nitrogen is presented in Table 3. Irrespective of the number and weight, grade B and C tubers occupied the greater percentages. Grade A and D tubers hold the minimum percentages by both number and weight bases, respectively. The results revealed that the percentages of grade A and B tubers were decreased and grade C and D tubers were increased with the increase in eyes number in cut seed tubers both in the number and weight bases. But the trends of influences were however statistically insignificant.

The N_{240} gave the highest number of grade A tubers (8.7%) though there was no significant variation between N_{120}, N_{180} and N_{240}. The lowest number of grade A tubers (4.0%) was found from N_0. Identical trends with higher magnitudes were also observed in grade B tubers, but N_{60}, N_{120}, N_{180} and N_{240} revealed insignificant differences. The highest number of grade C tubers (52.2%) was obtained from N_0 and the lowest number (35.9%) from N_{240} that was statistically similar with other N levels. Variation of grade D tubers as affected by

different levels of N was statistically insignificant, however, N_0 and N_{120} produced the maximum (26.5%) and minimum (20.1%) numbers, respectively. The tuber size grading by weight basis as affected by the different levels of nitrogen was almost identical with the tuber size grading by number (as described above) except grade D tubers, where the variations were statistically significant.

The Combined Effect: The combined effect of eyes number in cut seed tuber and different N levels produced insignificant variation in grade D tubers by both number and weight bases (Table 4). Grade A and B tubers also showed insignificant variations by percentage of number. The highest (58.0%) and lowest (31.9%) number of grade C tubers were obtained from $E_3 \times N_0$ and $E_1 \times N_{240}$ combinations, respectively. In weight basis, the highest grade of A, B and C sized tubers were found from the interactions of $E_1/E_2 \times N_{240}$, $E_1 \times N_{60}/N_{240}$ or $E_2 \times N_{60}/N_{180}$ or $E_3 \times N_{60}$, $E_3 \times N_0$ and $E_2 \times N_0$, respectively.

It was clearly demonstrated from the present observation that potato tuber yield was gradually increased with increasing N levels and the highest yield was obtained from 240 KgN ha^{-1} which was statistically identical with 180 Kg ha^{-1} indicating that application of N fertilizer beyond 180 Kg ha^{-1} might not be useful. Cut seed tuber piece containing 2 and 3 eyes were statistically similar in respect of tuber yield, but gave higher yield than that containing single eye. So, 2-eyed cut seed tuber may be useful as planting material from the economic point of view. The best treatment (s) for the grading of tuber size may be selected as per need. By judging the all performances, the best treatment combination (s) may be chosen according the requirement of uses such as table purposes, agro-industrial manufacturing, storing, seeds or planting materials and so on. However, further intensive researches are essential to improve production and quality of this crop through the above-described management.

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