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TO WORK OUT THE INTERACTIVE USE OF NITROGEN LEVEL AND TUBER SIZE ON GROWTH AND YIELD OF POTATO TUBER (*SOLANUM TUBEROSUM L.)*

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Abstract

A field experiment was carried out during winter (*Rabi*) season of 2016-17, at the instructional farm, AKS University, Satna, Sherganj, Madhya Pradesh. An experiment entitled "To work out the interactive use of nitrogen level and tuber size on growth and yield of potato tuber (*Solanum tuberosum* L.) cultivar Kufri Badshah*"* . The experiment considered of twelve treatment combinations comprising four levels of nitrogen *i.e.* 0kg, 80kg, 100kg & 120kg nitrogen/hectare and three tuber sizes of potato *viz.,* (25g, 35g and 45g). The experiment was laid out in Randomized Block Design with factorial concept with three replications. Growth parameters like plant height, number of leaves/plant, number of branches, number of tuber plant, fresh weight of tuber, stem diameter, dry weight of tuber and number of tuber/hectare. The highest tuber yield (29.54t/ ha) of potato have been obtained from tuber size *viz.,* 45g. The different nitrogen levels caused significant variations in tuber yield of crop.

Key word: Potato (*Solanum tuberosum* L.), Effect of nitrogen, Tuber size, yield.

Introduction

Potato (*Solanum tuberosum* L.) is one of the most important vegetables having high production per unit area as well as per unit time. Potato production can effectively help not only in enhancing potato requirement of large segment of population, however produces more calories per unit time than any other major food crops. India is the third largest producer of potato in the world after China and Russia. The area under potato cultivation in Indian is about 1.40 million hectare with production of 25 million hectare with production of 25 million tonnes and average productivity of 17 t/ha. It is grown almost in all the states of India except Kerala. Manorial requirement of potato crop is quite high and the application of fertilizer and organic manures are considered essential to obtain high economic yields (Grewal, 1990). The potato plants with sufficient nitrogen are characterized by vigorous growth, increased leaf area, large tuber size as well as number of tuber. Nitrogen is the major nutrient in potato production and much variability exists in nitrogen requirements between cultivars. Cultivars generally show increased yield as nitrogen rate is increased (Belanger *et al.*, 2000 and Arsenault *et al.*, 2001). However, excessive nitrogen lead to poor tuber quality, delayed crop maturity and excessive nitrate leaching, while nitrogen deficiency usually result in poor growth and low yields. Nitrogen is necessary to the potato from germination to maturity. The demand for this nutrient increases rapidly after germination and falls when 75 percent of the plant growth is completed. Any delay in making this nutrient available, particularly during early active phases of growth, result in a set back to the crop. Information on the optimum dose of nitrogen to be applied for potato crop under different agro-climatic condition is necessary for a judicious use of fertilizer and also to obtain higher yields. Fertilizer trails conducted during the past years at the regional centers of the Central Potato Research Institute, have shown that potato invariably responds to inorganic nitrogen, phosphorus and potash, Hence, it was considered appropriate to initiate the research work on nitrogen requirement for the crop grown through seed

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tubers, as nitrogen is primarily important for the crop and on the other hand, soils of M.P. state are also deficient in nitrogen. The size of cut seed piece is important which influences the growth and yields of potato. The cost of potato production is very high, and the cost of seed potato is generally occupies nearly 40% of the total cost of production. But the size of cut tuber pieces not yet been well-defined to get the maximum yield and economic return. Total number of eyes in a cut seed piece influences the number of shoot per hill and also the vegetative growth and foliage coverage, and ultimately the (Siddique *et al.*, 1987). The newly developed varieties of potato eventually react differently towards applied nitrogen and size of cut seed pieces of tubers under different agro-climatic conditions.

Materials and method

The present investigation was carried out in the well protected field of the experimental farm, AKS University, Satna, (M.P.). The field experiment was conducted during *Rabi* (winter) season of 2016-17.

Details of the experiments

Factor –A

Levels of nitrogen -4	Treatment symbols
0 kg N/ha	N_0
80 kg N/ha	N_1
100 kg N/ha	N_2
120 kg N/ha	N_3

Factor –B

Tuber size- 3

25 g	W_1
35 g	W_2
45 g	W_3

Observations

The methods adapted to record different observations on growth as well as yield contributing traits are given as below:

(A) Growth parameters

(I) Plant height : The plant height was measured in centimeter from ground level to the top of the plant at an interval of 30, 60 DAS and at harvest. Five competitive plants were randomly-selected and tagged to record the observations. The average was calculated.

(II) Number of leaves per plant : The number of leaves per plant was recorded on randomly selected five tagged competitive plants in each treatment at an interval of 30, 60 DAS and at harvest. The average was calculated.

(III) Number of branches per plant : Number of branches per plant was recorded on randomly selected 5 tagged competitive plants at an interval of 30, 60 DAS and at harvest. The average was calculated.

(IV) Stem diameter : The stem diameter was recorded on the randomly-selected five plants in each treatment at an interval of 30, 60 DAS and at harvest. The average was worked out.

(B) Yield parameters

(I) Fresh weight of tuber per plant (g) : Fresh weight of tubers (g) was recorded on already uprooted three competitive plants at harvest stage.

(II) Dry weight of tubers/plant (g) : After recording the fresh weight of tubers per plant, the separated plant material was then transferred in hot air oven at 60°C for 24 hours for removal of moisture. Hot air dried separated plant parts were weighed in gram.

(III) Tuber yield (t/ha) : Total tuber yield was recorded on individual net plot basis in kg/plot and was converted in t/ha.

Results and discussion

The data were recorded from the experiment conducted during winter season of 2016-17 at the Instructional farm, A.K.S. University, Satna (M.P.). The periodical data recorded from the field as well as from chemical laboratories under 12 treatment combinations were subjected to statistical computation and thereafter these are presented in the tables.

(A) Growth parameters

(i) Plant height : The periodical observations recorded on plant height at 30 days intervals are presented in table 1. The plant height enhanced steadily with the

Table 1: Plant height of potato at different intervals as influenced by N-levels and size of tuber.

Treatments	Plant height (cm)		
	30DAS	60 DAS	At harvest
N-levels (kg/ha)			
0	8.88	26.46	53.94
80	12.37	23.60	60.37
100	16.50	41.36	70.27
120	21.14	47.44	77.93
S.Em±	0.19	0.44	1.19
C.D. (P=0.05)	0.55	1.29	3.49
Tuber size (g)			
25	13.77	35.59	63.30
35	14.62	37.00	66.12
45	15.79	39.05	67.47
S.Em±	0.16	0.38	1.03
C.D. (P=0.05)	0.48	1.12	3.03
Interaction	**Sig**	**NS**	**NS**

enhancement of plant growth up to the harvest stage. The height at the initial stage on 30 DAS, in general, ranged from 8.88 to 21.14 cm under various treatments. The height went up to more than thrice up to the harvest stage *i.e.* ranging from 53.94 to 77.93 cm under different treatments. As regards with the applied treatments, nitrogen levels exerted significant influence upon this parameters at every stage of observations. The increasing levels of nitrogen up to N_{120} increased the plant height almost significantly at every stage. Accordingly, at the harvest stage, the plant height went up to 77.93 cm due to N_{120} as against only 53.94 cm under N (no nitrogen). Thus N_{120} proved significantly superior to rest of the N-levels at every stage of observations.

(ii) Number of leaves/plant : The number of leaves/ plant was counted treatment wise periodically and the data so obtained were subjected to statistical analysis. The data highlighted in table 2. through indicate that the leaves formation was encouraged steadily with the increase of plant growth. Accordingly the leaves formation became more than three fold up to the harvest stage. At 30 DAS, the leaves, in general, ranged from 8.98 to 17.27/ plant in different treatments. At harvest stage the leaves count reach from 43.18 to 58.29/plant due to various treatments.

Table 2: No. of leaves/plant of potato at different intervals as influenced by N-levels and size of tuber.

Treatments	Number of leaves/plant		
	30DAS	60 DAS	At harvest
N-levels (kg/ha)			
0	8.98	23.23	43.18
80	11.99	27.77	48.00
100	15.18	33.24	54.04
120	17.27	37.99	58.29
S.Em±	0.15	0.19	0.18
C.D. (P=0.05)	0.45	0.55	0.53
Tuber size (g)			
25	13.17	30.34	50.60
35	13.40	30.51	50.73
45	13.49	30.83	51.31
S.Em±	0.13	0.16	0.16
C.D. (P=0.05)	NS	NS	0.47
Interaction	**NS**	**NS**	**Sig.**

(iii) Number of branches/plant : The number of branches/plant of potato was recorded treatmentwise periodically and the data after statistical analysis are highlighted in table 3. This parameter was enhanced with the age of this crop up to harvest stage. The formation of branches at 30 DAS stage ranged from 1.09 to 1.93/ plant in different treatments. The branches enhanced up to more than twice at harvest stage *i.e.* 1.11 to 4.73/plant due to various treatments.

Table 3: No. of branches/plant of potato at different intervals as influenced by N-levels and size of tuber.

Treatments	No. of branches/plant		
	30DAS	60 DAS	At harvest
N-levels (kg/ha)			
0	1.09	1.68	3.11
80	1.23	1.92	3.69
100	1.62	2.19	4.13
120	1.93	2.48	4.73
S.Em±	0.10	0.03	0.06
C.D. (P=0.05)	0.28	0.10	0.19
Tuber size (g)			
25	1.37	2.00	3.73
35	1.42	2.07	3.93
45	1.62	2.13	4.09
S.Em±	0.08	0.03	0.05
C.D. (P=0.05)	0.24	0.09	0.16
Interaction	**NS**	**NS**	**NS**

(iv) Stem diameter : The periodical observations on stem diameter were recorded under each treatment and the data thus obtained were statistically computed. The results presented in table 4. The indicate that the stem diameter of potato was enhanced at the faster rate between 30 and 60 DAS growth period thereafter increased very slightly up to the harvest stage. The stem diameter, in general, ranged from 3.38 to 4.49 cm at 30 DAS in different treatments. At harvest stage it ranged from 5.60 to 6.24 cm.

Table 4: Stem diameter of potato at different intervals as influenced by N-levels and size of tuber.

Treatments	Stem diameter (cm)		
	30DAS	60 DAS	At harvest
N-levels (kg/ha)			
0	3.38	5.18	5.60
80	3.65	5.36	5.72
100	3.99	5.56	5.85
120	4.49	5.71	6.24
S.Em±	0.08	0.02	0.04
C.D. (P=0.05)	0.24	0.06	0.11
Tuber size (g)			
25	3.79	5.40	5.78
35	3.87	5.44	5.85
45	3.98	5.51	5.93
S.Em±	0.07	0.02	0.03
C.D. (P=0.05)	NS	0.05	0.09
Interaction	**NS**	**NS**	**Sig**

(B) Yield-attributing characters

(i) Number of tubers/plant (kg) : The data pertaining to number of tubers/plant was obtained from each treatment. The mean data were subjected to statistical analysis and thereafter presented in table 5. This yield-attributing parameter was influenced significantly due to nitrogen levels but not due to tuber size as well as their interactions. There was significant increase in number of tubers/plant up to N_{120} level of nitrogen where the number of tuber was 27.33/plant. The tubers count was significantly lowest (20.27/plant) in case of without nitrogen.

Table 5: No. of tubers/plant of potato at harvest as influenced by N-levels and size of tuber.

Nitrogen levels (kg/ha)	Size of tuber (g)			
	25	35	45	Mean
0	20.67	21.07	19.07	**20.27**
80	22.27	22.33	24.20	**22.93**
100	24.40	24.60	25.20	**24.73**
120	27.27	27.20	27.53	**27.33**
Mean	**23.65**	**23.80**	**24.00**	

(ii) Fresh weight of tubers/plant (g) : The perusal of data in table 6. the fresh tuber weight/plant was influenced significantly due to nitrogen levels but not due to size of tubers and the treatment interactions. Each increment in N-levels up to N_{120} brought about significant rise in the fresh tuber weight (194 g/plant). Thus, N_{100} was also found significantly superior to all the lower levels of nitrogen. The significantly lowest tuber weight (24.1 g) was obtained from without nitrogen. There was very slight rise in tuber weight due to increasing size of tubers, thus the fresh tuber weight ranged from 264 to 267 g/ plant.

Table 6: Fresh weight of tubers/plant (g) of potato at harvest as influenced by N-levels and size of tuber.

Nitrogen levels (kg/ha)	Size of tuber (g)			
	25	35	45	Mean
0	232	248	242	**241**
80	263	253	260	**259**
100	272	271	278	**274**
120	289	296	297	**294**
Mean	**264**	**267**	**269**	

(iii) Dry weight of tubers/plant : The dry weight of tubers/plant was obtained through weighing under different treatment combinations. The data so obtained were subjected to statistical analysis and then presented in table 7.

Application of nitrogen levels only exerted significant influence upon this parameter. In addition to tuber size, the treatment interactions were also found to be non-significant. This parameter changed up to significant extent due to nitrogen levels applied up to N_{120}. Accordingly, the maximum dry weight/plant noted (51.17 g) from N_{120}, followed by N_{100} (46.51 g) and then N_{80} (42.73 g). The significantly lowest weight (38.56 g) was noted from N_0. The increasing size of tubers brought about no any significant enhancement in dry weight of tubers, the value ranged from 43.95 to 45.25 g/plant. The dry weight was not influenced significantly due to N × tuber size interactions.

Table 7 : Dry weight of tubers/plant (g) of potato as influenced by N-levels and size of tuber.

Nitrogen levels (kg/ha)	Size of tuber (g)			
	25	35	45	Mean
0	36.85	39.42	39.41	**38.56**
80	42.39	42.80	43.01	**42.73**
100	46.25	46.58	46.68	**46.51**
120	50.31	51.30	51.89	**51.17**
Mean	**43.95**	**45.03**	**45.25**	

(iv) Number of tubers/plant : The number of tubers/plot was obtained through counting under different treatment combinations. The data so obtained were subjected to statistical analysis and then presented in table 8.

Table 8: No. of tubers/plot of potato as influenced by N-levels and size of tuber.

Nitrogen levels (kg/ha)	Size of tuber (g)			
	25	35	45	Mean
0	111	112	113	**112**
80	118	118	120	**119**
100	125	126	130	**127**
120	132	132	132	**132**
Mean	**121**	**122**	**124**	

(v) Tuber yield (t/ha.): The tuber yield per hectare was obtained from the various treatment combinations after converting plot-wise yield into q/ha. The data were statistically computed and then presented in table 9. The straw yield was influenced significantly due to applied

Table 9 : Tuber yield (t/ha) of potato as influenced by N-levels and size of tuber.

Nitrogen levels (kg/ha)	Size of tuber (g)			
	25	35	45	Mean
0	18.87	22.97	23.20	**21.68**
80	24.13	25.30	26.20	**25.21**
100	26.27	26.57	28.43	**27.09**
120	29.10	29.33	30.20	**29.54**
Mean	**24.59**	**26.04**	**27.01**	

nitrogen levels and tuber size as well as their interactions.

This chapter deals with the probable explanation and interpretations of the treatments effect which as being briefly discussed below in the light of the research work already done by other research workers in India and abroad.

(vi) Plant height : It is obvious from the data the significant difference in plant height was observed at all the stages of observation (30, 60 DAS and at harvest) due to tuber size and varying levels of nitrogen in potato (table 1), there was slow growth of potato plants up to 30 DAS and thereafter, there was sharp increase in plant height up to harvest stage. The highest plant height was recorded by largest 45 g tuber size at all the stages of plant growth, which was found significantly superior than all the lower tuber size in this study. The lowest plant height was observed in 25 g tuber size at every stage of case of observations. At harvest stage, 45 g tuber size recorded maximum plant height upto 67.47 cm as against only 63.30 cm under smallest tuber size (25 g). It was primarily due to high food reserve in large size tubers. The results observed in this investigation for plant height are in close proximity with the findings of Singh (1995), Singh and Raghav (2000). They also reported the increase in plant height of potato with high nitrogen level. Interaction effects were found to be non-significant for this trait under 60 DAS and harvest stages of potato (table 4). However, N_{120} + 45 g tuber size recorded maximum plant height at every stage.

(vii) Number of branches per plant : The number of branches per plant at 30, 60 DAS and at harvest are presented in table 04. The data showed that the number of branches per plant increased with the increase in age of the plant upto harvest stage. The tuber size of 45 g recorded significantly more number of branches per plant as compared to 25 g tuber size only. This trend was noticed at every stage of observations. At harvest stage, the maximum branches were 4.09/plant under 25 g tuber size. The varying levels of nitrogen showed significant effect upon the number of branches per plant at all the stages of growth (30, 60 and at harvest). At harvest stage, the significantly higher number of branches (4.73 per plant) were recorded by the nitrogen level 120 kg/ha, as compared to the lower levels of nitrogen. On the other hand, the lowest number of branches (3.11/plant) was recorded under without nitrogen. The maximum branches formation due to increased nitrogen has been reported by several research workers (Singh and Raghav, 2000; Patel and Patel, 2001).

(viii) Number of leaves per plant : The data regarding the number of leaves per plant are presented in table 2. It is revealed from the data that the significantly highest number of leaves per plant was recorded with 120 kg N/ha over the preceding N-levels at every stage. At harvest stage, the maximum leaves count was 58.29/ plant as against only 42.18/plant under no nitrogen. This incase uptake of nutrients, which resulted in increased synthesis of due to increased of carbohydrates, which are utilized in buildind up of new cell. These results are in conformity with the findings of Malik *et al.*, (1998). Ali and Chattopadhyay (2006). As regards with the effect of size of tuber, larger 45 g tuber size recorded non-significantly highest leaves count (13.49 and 30.83/plant at 30 and 60 DAS, respectively) and significantly highest (51.31/plant) at harvest stage. The smallest tuber size (25 g) recorded the minimum leaves count at every stage. The similar results have been reported by Nandekar (2005), Ali and Chattopadhyay (2006). The treatment interactions, although were found to be non-significant at 30 and 60 DAS .The minimum leaves count/plant was observed from N_{120} with 45 g tuber size at every stage of observations. In contrast, the minimum leaves count was noted from N_0 with 25 g tuber size. This trend was in accordance with the treatments effect in combination.

(ix) Stem diameter : The perusal of data in Summary table 4. reveal that the stem diameter was influenced significantly due to N-levels at every stage of observations. At harvest stage, N_{120} resulted in significantly highest stem diameter (6.24 cm) over all the preceding N-levels. Whereas the lowest stem diameter (5.60 cm) was noted in case of without nitrogen. The largest 45 g tuber size enhanced the stem diameter upto significant extent at 60 DAS and harvest stages. At harvest stage, 45 g tuber size resulted in 5.93 cm stem diameter, being significantly higher to 25 and 35 g tuber size. The smallest tuber size 25 g recorded the lowest stem diameter (5.78 cm).

(x) Yield-attributes : It is apparent from the data that the highest level of nitrogen (N_{120}) resulted in significantly highest yield-attributes *viz*. number of tubers (27.33/plant), fresh weight of tubers (294 g/plant), dry weight of tubers (51.17 g/plant) and number of tubers (132/plot) as compared to the preceding N-levels. These results are fairly comparable to the results reported by many researchers (Patel *et al.*, (2000). The largest seed tuber size (45 g) recorded non-significantly highest number of 24 tubers/plant, fresh and dry weight of tubers (269 and 45.25 g/plant, respectively) and significantly highest 124 tubers/plot as compared to the smaller (25 and 35 g) seed tuber size.

(xi) Tuber yield/ha The yield of any crop depends on its capacity to accumulate photosynthates per unit time

and its ability to remobilize the photosynthates towards the sink *i.e.* yield-attributes and yield. In case of tuber a plant with better partitioning ability and high remobilization of accumulated assimilates to develop underground tuber may lead to high tuber yield. In this respect the application of nitrogen upto N_{120} gave significantly higher tuber yield (29.54 t/ha) which was higher by 7.86 t/ha over no nitrogen and higher by 2.45 t/ha over N_{100}. Such an increase in tuber yield might be due to maximum increase in the yield-attributes under N_{120}. These findings are in conformity with those of Yenagi *et al.* (2005) and Bhat *et al.* (2005). The largest seed tuber size (45 g) resulted in significantly higher tuber yield (27.01 t/ha) which was higher by 2.42 t/ha over smallest (25 g) seed tuber size. Such an increase in tuber yield may be ascribed to the maximum increase in yield-attributes (number of tubers/ plant and/plot and their fresh weight) under the largest tuber size (45 g). Similar results trend has also been observed by many research workers as already mentioned in case of yield-attributes.

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