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ENHANCING NITROGEN USE EFFICIENCY THROUGH VARIED LEVELS OF NITROGEN APPLICATION – ITS IMPACT ON GROWTH AND YIELD OF POTATO UNDER NEW ALLUVIAL SOIL OF WEST BENGAL INDIA

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ABSTRACT

A field experiment was carried out during the *rabi* seasons of consecutive couple of years 2022-23 and 2023-24 at the District Seed Farm- C Unit (22°58'45"N, 88°25'15"E, 10m elevation) of BCKV in Kalyani, West Bengal, to optimize the nitrogen dosage with special reference to nitrogen use efficiency for the improved potato cultivar Kufri Himalini in the lower Gangetic plains of West Bengal. The experiment was conducted in Randomized Block Design with 8 treatments (T_1: zero N; T_2: N @50 kg/ha; T_3: N @100 kg/ha; T_4: N @150 kg/ha; T_5: N @200 kg/ha; T_6: N @250 kg/ha; T_7: N @300 kg/ha; T_8: N @350 kg/ha) replicated thrice. All the treatments received same amount of P_2O_5 and K_2O @150 kg/ha each. The results revealed that the treatment T_8 (N @350 kg/ha) performed better than all other treatments in terms of plant growth parameters, while the treatment T_7 (N @300 kg/ha) documented the highest tuber yield and marketable grade tuber yield (>75g), superseding by 24.52% over the recommended dose of fertilizer (RDF) (200:150:150kg/ha N: P_2O_5: K_2O). Additionally, T_7 had the highest N, P and K uptake, surpassing RDF by 27.01%, 31.08% and 9.34%, respectively. It was observed that as the rate of nitrogen application increased, physiological efficiency gradually increased while agronomic efficiency and the apparent recovery of fertiliser N gradually decreased. In case of production economics, T_7 recorded the highest net return and B: C ratio (2.27). So, the application of nitrogen @300kg along with 150kg P_2O_5 and 150kg K_2O per hectare can be recommended for better growth, yield and higher profits in potato cultivation under lower Gangetic plains of West Bengal.

***Keywords*:** Nitrogen levels, Potato, Kufri Himalini, Yield, NUE, Marketable tuber.

Introduction

Potato (*Solanum tuberosum* L.) being a significant Solanaceous tuber crop has gained an enormous importance as a non-cereal food crop across the globe and is cultivated in around 150 countries. According to FAOSTAT (2023), global potato production reached the level of 376.1 million tonnes in the year 2021. This very underground crop holds a prominent position in the field of horticulture and has been ranked as the third most important staple food for human consumption, after wheat and rice (Devaux *et al.*, 2020). Presently, India is the second largest producer of potato in the world after China, covering an area of around 2.25 million ha producing 54.23 million tonnes (Anonymous, 2021). The pivotal role of the CPRI after its establishment (1949) in spreading the cultivation of this crop across the country made the grand success in area expansion as well as production escalation of this very crop. At present, more than 80% of its area is being concentrated in the Indo-Gangetic plains, with about 74 percent of this area in the states of Uttar Pradesh, Bihar, and West Bengal producing 82% of the country's total potato (Horticulture Statistics Division Department of agriculture and Cooperation). Among the states, West Bengal, primarily a rice growing sate, becomes the second largest producer of potato with an area of 4.47 lakh ha and production of 124.03 lakh tonnes (Anonymous, 2022) after Uttar Pradesh during 2021-22.

Potatoes possess a good source of vitamins, specifically vitamin B and C together with several essential minerals. Based on the findings of Banu *et al.* (2007), tubers are composed of approximately 70-80% water, 20.6% carbohydrates, 2.1% protein, 0.3% fat, 1.1% crude fibre and 0.9% ash. The potato crop produces the highest dry matter and edible protein per unit area per unit time amongst all the major food crops. Along with some other crops potato is essential for food security to feed the world's mammoth population (Thiele *et al.*, 2010; Scott and Sourez, 2012).

Efficiency of nitrogen in rhizosphere soil impacts plant growth and development. A judicious supply of nitrogen promotes the formation and growth of roots as well as the uptake of other nutrients (Brady & Weil, 2008). The overuse of nitrogenous fertilisers results in significant nitrogen losses and low NUE, through leaching and an increase in the reactive nitrogen component of soil water and the atmosphere, ultimately disrupting the ecosystem (Singh and Lal, 2012). Furthermore, excess nitrogen application leads to poor tuber quality and delayed crop maturity, whereas, nitrogen deficit results in early nitrogen translocation from the leaves to the tubers, which could result in premature senescence in the plants (Saluzzo *et al.*, 1999).

33.33% of the national demand for potato is being provided by the state of West Bengal. The absence of high-quality seed, carrying with outdated fertilizer, non-responsive cultivars and indiscriminate use of fertilisers are the main issues with potato farming in this region. Hoping to have affluent yield through pouring more and more chemical fertilizers, especially nitrogenous one, potato farmers of the eastern India reached to such a level during last three decades that now it can be undoubtedly felt to be indiscriminate rather imbalanced use of chemical fertilizers. By introducing enhanced potato cultivars with higher yield potential and implementing appropriate nutrient management techniques, this problem can be resolved (Das *et al*., 2015). Even though optimum N rates depend on a variety of factors, research has shown that a slight reduction in N inputs does not reduce crop output (Luo *et al*., 2018), but rather increases N use efficiency (Zhang *et al*., 2015). As a result, nitrogen dose must be optimised under lower Gangetic plains of West Bengal.

Kufri Himalini, a medium-maturing variety with medium-sized, oval-oblong white tubers and pale-yellow flesh, is known for its excellent cooking and preserving qualities. It could be a promising choice for the new alluvial zone of West Bengal, yielding more than Kufri Jyoti, Kufri Giriraj and Kufri Shailja. In regions where late blight is a recurring issue, this variety may offer stability to potato farming (Joseph *et al*., 2007).

With these facts and figures keeping in the background the present experiment was conducted with Kufri Himalini under a Randomized Complete Block Design, incorporating eight nitrogen levels and three replications. The study aims to assess the effects of varying nitrogen levels on potato growth, yield, nutrient uptake, nitrogen use efficiencies and the economic viability of potato production in the lower Gangetic plains of West Bengal. The results will provide valuable insights into optimizing nitrogen fertilization for enhanced crop productivity while minimizing nitrogen losses to the environment.

Materials and Methods

The field experiment was carried out during two consecutive *rabi* (winter) seasons of 2022-23 and 2023-24 at the District Seed Farm- C Unit (22°58'N latitude, 88°25'E longitude and 9 meters above mean sea level), Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal, India. The experimental soil was characterized as sandy loam type having pH of 7.42, organic carbon content of 0.57% and available macro-nutrients *viz.* 182.25 kg nitrogen, 16.85 kg phosphorus and 133.00 kg potassium per hectare. The experiment was arranged in Randomized Block Design with 8 treatments (T_1: N @0 kg/ha; T_2: N @50 kg/ha; T_3: N @100 kg/ha; T_4: N @150 kg/ha; T_5: N @200 kg/ha; T_6: N @250 kg/ha; T_7: N @300 kg/ha; T_8: N @350 kg/ha, where all the treatments received recommended dose of phosphorous and potassium @150 kg/ha each) replicated three times. Urea, single super phosphate and muriate of potash were used as the source of N, P_2O_5 and K_2O, respectively. All the fertilizers were applied as basal at the time of final land preparation except urea which was applied in splits; half of which was applied as basal and another half was top dressed at the time of earthing up at 30 days after planting (DAP). Other agronomic management techniques were used consistently in all the treatments throughout the cropping season based on suggested guidelines (Rana *et al*., 2014). The cultivar used was Kufri Himalini producing higher yields and it is resistant to late blight. It has good tuber dry matter content and improved storage quality as well (Joseph *et al*., 2007). Pre-harvest analysis like plant emergence percentage, plant height, number of shoots per plant, number of compound leaves per plant, leaf area index (LAI), crop growth rate (CGR), tuber bulking rate (TBR) and dry matter accumulation were measured/derived utilising the methodology suggested by Watson (1952). Once the potato was harvested, the tubers were weighed separately to record yield and categorized into three grades based on tuber weight: <25g, 25-75g and >75g for each plot. Total tuber yield, grade-wise tuber number and yield, total dry weight yield of haulms and tubers as well as harvest index were measured. Soil samples (0-15cm depth) were collected from each treatment plot to analyse available N after harvest. Plant analysis was also conducted to determine total N uptake from the soil. Nitrogen use efficiencies like agronomic efficiency (AE_N), apparent recovery (RE_N) and physiological efficiency (PE_N) of fertilizer N was enumerated using the formula given below (Singh and Singh, 2012).

$$AE_N = \frac{Y_N - Y_C}{N_a} \qquad RE_N = \frac{U_N - U_C}{N_a} \qquad PE_N = \frac{Y_N - Y_C}{U_N - U_C}$$

Where 'Y' and 'U' represent potato yield and N uptake, respectively; 'N' represents the plots receiving nitrogen and 'C' stands for control plots and 'a' for the amount of applied nitrogenous fertilizer. All figures are expressed in kg/ha.

Cost of cultivation, gross and net return, benefit-cost ratio and incremental cost benefit ratio (ICBR) was computed. ICBR was calculated by the following formula given by Sheoran *et al.* (2013).

$$ICBR = \frac{GR_T - GR_{RDF}}{TCP_T - TCP_{RDF}}$$

Where, GR_T refers to the gross return of the treatment, GR_{RDF} illustrates the gross return of the RDF treatment, TCP_T represents the total cost of production of the treatment and TCP_{RDF} denotes the total cost of production of the RDF treatment.

Pooled data of a consecutive couple of years (2022-23 and 2023-24) were taken for finalizing the results drawn during due discussion. The tables of results include the standard error of mean [SEm (±)] and the value of the critical difference (CD) at a significance level of 5%. These statistical values were provided to facilitate the comparison of mean values.

Results and Discussion

Growth attributes

The pooled data of field experiments conducted during both the years of experimentation showed no significant difference in emergence percentage and number of shoots per plant across different nitrogen doses practiced in potato crop (Table 1). However, the plant height, leaves per plant and LAI measured/ derived at 70 DAP, were increased significantly with increasing nitrogen doses. The application of a higher dose of nitrogen (T_8: 350 kg/ha) resulted in a significantly taller plants at 70 DAP, exhibiting an increment in 87.85% height compared to the control plot (T_1). A notable augmentation in the production of compound leaves was observed as the nitrogen levels were raised from 0 to 350 kg/ha (32.75-69.25 Nos/plant). The maximum LAI (2.77 at 70 DAP) was observed when the potato crop was fertilized with 350 kg N/ha (T_8). There was a progressive increase in dry matter accumulation across all treatments as the crop gradually attended maturity (Figure-1). The lowest accumulation was observed under the treatment T_1 (41.42 g/m² at 30 DAP to 387.35 g/m² at 90 DAP), whereas, the highest was recorded under T_8 (57.33 g/m² at 30 DAP to 1012.74 g/m² at 90 DAP), reflecting a positive impact of increased nitrogen levels on dry matter accumulation. It was also clear that crop growth rate (CGR) and tuber bulking rate (TBR) were increased significantly with the increasing rate of nitrogen levels. The treatment T_8 exhibited the highest value of CGR (11.17 g/m²/day at 30-50 DAP). However, the treatment T_7 recorded the maximum CGR (8.62 g/m²/day at 50-70 DAP). Interestingly, at 50-70 DAP, TBR was found to be the maximum under the treatment T_8 (11.20 g/m²/day). Though, at later stage of growth (70-90 DAP) its higher value was observed under the treatment T_7 (6.08 g/m²/day). The application of higher dosage of nitrogenous fertilizer might promote improved nitrogen uptake by the haulm leading to the development of larger canopy in profusely fertilized crops. Similar results regarding enhanced growth attributes of potato, including plant height, LAI, dry matter accumulation, CGR and TBR in response to varying nitrogen levels have been reported by Das *et al.* (2015), Mozumder *et al.* (2014) and Kumar *et al.* (2009).

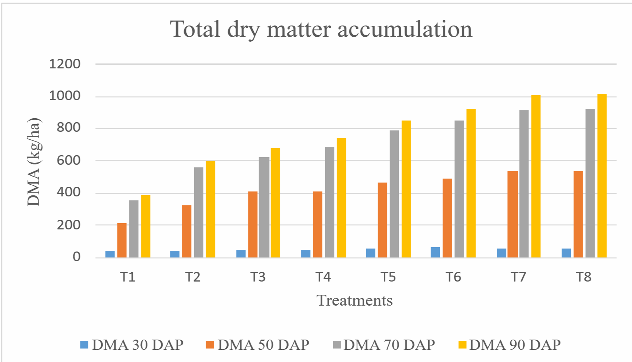

Fig. 1: Dry matter accumulation in potato

Dry weight of haulm and tuber and percent dry matter of potato tuber

The dry weight of haulm increased consistently with rising nitrogen levels, reaching its peak at 4.12 t/ha under treatment T_8, indicating enhanced vegetative growth in response to greater nitrogen availability (Table 3). Similarly, the dry weight of tubers showed a progressive increase from 2.11 t/ha (T_1) to a maximum of 5.96 t/ha (T_7), beyond which it slightly declined in T_8, suggesting that while optimal nitrogen levels stimulate tuber development, excessive application may result in luxury consumption without further yield benefits. In contrast, the tuber dry matter content (%) exhibited a gradual decline with increasing nitrogen levels, decreasing from 17.03% at T_1 to 16.07% at T_8. This inverse relationship indicates that higher nitrogen availability may lead to increased water content in tubers, thereby reducing their dry matter accumulation.

Yield components, yield and harvest index of potato

The experiment demonstrated a significant influence of different nutrient management practices on yield components and overall potato yield, as observed in the pooled data of both the years. The data presented in Table 4 indicates a significant impact of nitrogen application on tuber size distribution and total tuber number. Among the different treatments, T_5 (150 kg N/ha) recorded the highest number of marketable tubers (>75g) of 171,880 ha^{-1} and this treatment was statistically followed by T_4 and T_8. The smallest tuber fraction (<25g) showed a declining trend with increasing nitrogen levels, with the lowest count observed under T_4 (46.66) and the highest in the control treatment T_1 (168.85). Similarly, the application of nitrogen increased the yield of medium (25-75g) and large-sized (>75g) tubers, while the yield of smaller sized tubers (<25g) declined with higher nitrogen doses. Among the treatments, T_7 (300 kg N/ha) recorded the highest total tuber yield (36.72 t/ha), and this treatment was closely followed by T_8 (350 kg N/ha) reflecting a yield of 36.63 t/ha. The yield of marketable tubers was also the highest under T_7 (21.16 t/ha) and T_8 (20.40 t/ha), demonstrating that nitrogen application significantly promotes the production of marketable tubers. The yield of medium-sized tubers (25-75g) showed an increasing trend with nitrogen application, peaking at T_7 (14.62 t/ha), followed by T_8 (14.59 t/ha), highlighting the role of nitrogen in enhancing tuber bulking. Conversely, the smallest tuber (<25g) yield was declined with increasing nitrogen levels, showing the lowest value in T_4 (0.58 t/ha) and the highest in T_1 (2.40 t/ha). Balanced nitrogen application is crucial for optimizing tuber yield by promoting the formation of larger, marketable tubers while reducing the proportion of unmarketable small tubers, as the prompt nutrient application facilitates rapid nutrient release, enhancing vegetative growth and boosting carbohydrate synthesis and translocation (Sarkar *et al.*, 2011). The harvest index, representing the proportion of total biomass allocated to tubers, ranged between 0.51 and 0.60, with higher values observed in optimal nitrogen treatments (T_7 and T_8). These findings underscore the importance of precise nitrogen management in optimizing the tuber yield.

Nitrogen use efficiency (NUE) of potato

The nitrogen use efficiency (NUE) of potatoes is crucial for optimizing yield and resource utilization. As shown in Table 5, the agronomic efficiency of fertilizer nitrogen (AE_N) declined with increasing nitrogen levels, ranging from 106.67 kg/kg at 50 kg N/ha (T_2) to 69.24 kg/kg at 350 kg N/ha (T_8), indicating diminishing returns at higher applications. Similarly, the apparent recovery of nitrogen (AR_N) decreased from 1.03 at 50 kg N/ha (T_2) to 0.42 at 350 kg N/ha (T_8), advocating reduced nitrogen uptake efficiency with excessive fertilization. However, physiological efficiency (PE_N) improved with increasing nitrogen levels, reaching a peak of 135.53 kg/kg at the treatment T_8, delineating enhanced nitrogen translocation into biomass. These findings suggest that moderate nitrogen application enhances NUE, while excessive nitrogen leads to inefficiencies. This is consistent with the observations of Mozumder *et al.* (2014) and Kumar *et al.* (2009), who also reported reduced agronomic and recovery efficiencies at higher nitrogen levels, emphasizing the need for balanced fertilization to improve NUE in potatoes.ca

NPK uptake by potato

A significant variation in nutrient uptake was observed across all the treatments, with nitrogen uptake ranging from 24.30 kg/ha (T_1: 0 kg N/ha) to 210.36 kg/ha (T_7: 300 kg N/ha) as shown in Table 6. The highest nitrogen uptake (210.36 kg/ha) recorded under T_7 was statistically significant to T_8 (203.45 kg/ha with 350 kg N/ha). Similarly, phosphorus uptake varied from 9.44 kg/ha in T_1 to 36.02 kg/ha in T_7, while potassium uptake ranged from 37.35 kg/ha (T_1) to 149.12 kg/ha (T_7). The application of 300 kg N/ha (T_7) led to the highest recorded uptake of all three nutrients, closely followed by T_8 (350 kg N/ha), suggesting that increasing nitrogen application enhances nutrient absorption. However, beyond 300 kg N/ha, the increase in nutrient uptake was marginal, indicating a possible saturation point. These findings align with Kumar *et al.* (2009), who reported a significant increase in tuber-N content and uptake when nitrogen application was raised from 0 to 270 kg/ha.

Correlation study between tuber yield and NPK uptake

The correlation analyses indicated that the relationships between tuber yield and total nitrogen uptake (Eqn. 1), total phosphorus uptake (Eqn. 2) and total potassium uptake (Eqn. 3) were statistically significant, as demonstrated by the subsequent equations.

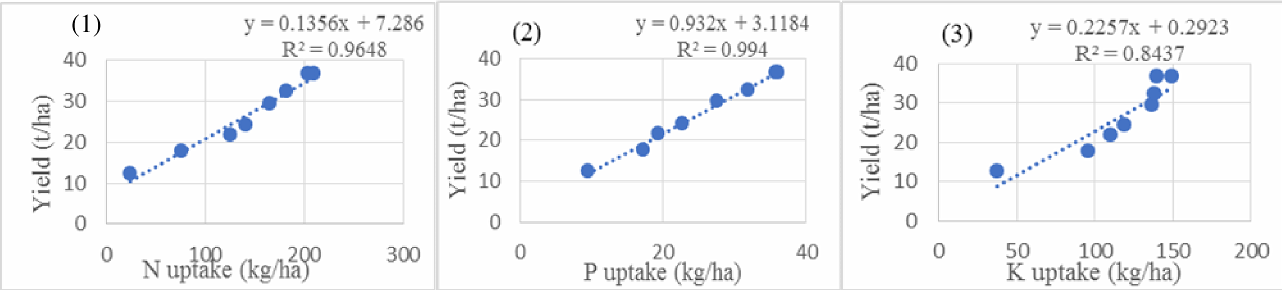

Fig. 2 : Correlation equations

Where, y represents tuber yield (t/ha). The tuber yield exhibited a linear and positive correlation with total NPK uptake, as demonstrated by the slopes and intercepts of the corresponding equations. The slopes of the equations suggested increases of 0.14, 0.93 and 0.23 t/ha in tuber yield per unit increase in total N, P and K uptake, respectively. The findings demonstrate that potato tuber production is predominantly influenced by total NPK absorption, with higher nitrogen levels leading to increased tuber yield. Additional studies have also noted a strong correlation between tuber production and overall NPK absorption (Mozumder *et al*., 2014).

Nitrogen balance

A nutrient balance sheet was prepared to gain a comprehensive understanding of the net gain or loss of nitrogen, phosphorus and potassium in the soil after harvest. All plots exhibited a negative balance of N (Table 7). The net loss of soil nitrogen exhibited a gradual increase as the levels of nitrogen application were raised up to 350 kg N/ha. The plot with the highest nitrogen level (T_8: 350 kg N/ha), experienced the greatest amount of nitrogen loss (166.45 kg/ha) after the potato harvest. In contrast, the lowest N loss (26.81 kg/ha) was observed in T_1 (zero-N) treatment, which may be attributed to minimal nitrogen leaching and volatilization in nitrogen-deficient conditions. Other researchers (Cabello *et al*., 2009; Badr *et al*., 2012) also observed a comparable pattern, wherein plants cultivated under excessive nitrogen (N) supply exhibited reduced extraction of nitrogen from the soil to meet the nitrogen demands of the crops.

Economic analysis

The economic analysis (Table 8) reveals that net returns from potato cultivation varied from Rs. -30,129/ha (T_1: zero-N) to Rs. 1,84,898/ha (T_7: 300 kg N/ha). The T_7 also exhibited the highest B:C ratio (2.27) and it was followed by T_8. In contrast, the lowest net return and B:C ratio (0.79) were observed under T_1. It might be due to restricted crop growth and lower productivity (Baishya *et al*., 2013). Higher nitrogen doses enhanced economic returns by improving total and marketable tuber yield (Das *et al*., 2015). The highest Incremental Cost-Benefit Ratio (ICBR) was recorded in T_7 with respect to both control (41.25) and RDF (23.78), indicating that nitrogen application at 300 kg/ha was the most cost-effective approach among all treatments.

Conclusion

Two years of research led to the conclusion that nitrogen dosages had an effect on growth, yield and nitrogen use efficiency of potato. The highest tuber yield and economics were obtained with the application of 300 kg N along with 150 kg P_2O_5 and 150 kg K_2O per hectare for potato cultivar Kufri Himalini. So, this dose can be recommended for better growth, yield and higher profits in potato cultivation under lower Gangetic soils of West Bengal. As agriculture faces evolving challenges, further research is essential to refine these strategies and integrate innovative approaches.

Table 1: Plant emergence and growth attributes of potato as influenced by different doses of nitrogen (pooled data of two years)

Treatments	Treatment details	Emergence (%)	Plant height at 70 DAP (cm)	Shoots/plant at 70 DAP	Leaves/plant at 70 DAP	LAI at 70 DAP
T_1	0 kg N/ha	98.05	46.67	3.00	32.75	0.65
T_2	50 kg N/ha	97.15	58.67	3.75	49.25	0.84
T_3	100 kg N/ha	98.52	60.67	4.25	52.75	1.22
T_4	150 kg N/ha	98.49	65.67	4.00	55.75	1.98
T_5	200 kg N/ha	96.21	70.33	3.00	57.25	2.57
T_6	250 kg N/ha	96.63	76.67	3.50	65.5	2.61
T_7	300 kg N/ha	97.96	85.33	3.25	66.75	2.65
T_8	350 kg N/ha	97.73	87.67	3.50	69.25	2.77
SEm (±)		0.19	1.70	0.86	3.27	0.04
CD (P=0.05)		NS	5.15	NS	10.00	0.11

Table 2: Crop growth rate and tuber bulking rate of potato as influenced by levels of N (pooled data of two years)

Treatments	Crop growth rate (g/m^2/ day)		Tuber bulking rate (g/m^2/ day)	
	30 -50 DAP	50-70 DAP	50 -70 DAP	70-90 DAP
T_1	3.50	3.06	3.69	2.45
T_2	6.06	7.24	4.57	2.96
T_3	6.77	7.23	3.62	3.80
T_4	7.18	8.03	5.52	4.30
T_5	9.35	7.22	8.70	4.91
T_6	9.14	8.30	9.89	5.34
T_7	9.85	8.62	10.64	6.08
T_8	11.17	8.03	11.20	5.93
SEm (±)	0.27	0.26	0.17	0.14
CD (P=0.05)	0.83	0.79	0.52	0.44

Table 3: Dry weight of haulm and tuber and percent dry matter of potato tuber as influenced by N levels (pooled data of two years)

Treatments	Dry weight of haulm (t/ha)	Dry weight yield of tubers (t/ha)	Tuber dry matter content (%)
T_1	1.60	2.11	17.03
T_2	2.89	2.96	16.67
T_3	3.06	3.59	16.60
T_4	3.28	4.00	16.50
T_5	3.56	4.83	16.37
T_6	3.83	5.26	16.27
T_7	3.92	5.96	16.23
T_8	4.12	5.89	16.07
SEm (±)	0.17	0.08	0.09
CD (P=0.05)	0.51	0.23	0.27

Table 4: Grade-wise tuber number and yield as well as total yield and harvest index of potato (pooled data of two years)

Treatments	Tuber number (000'/ha)				Yield (t/ha)				Harvest index
	<25g	25-75g	>75g	Total	<25g	25-75g	>75g	Total	
T_1	168.85	166.45	30.69	324.87	2.40	7.51	2.49	12.40	0.57
T_2	135.52	173.72	76.29	376.48	1.69	9.42	6.62	17.73	0.51
T_3	88.87	176.84	145.41	389.61	0.89	8.62	12.13	21.64	0.54
T_4	46.66	187.47	171.19	387.18	0.58	8.93	14.71	24.22	0.55
T_5	71.09	203.21	171.88	388.97	0.87	11.78	16.84	29.49	0.58
T_6	48.88	222.84	136.31	304.86	0.97	12.98	18.40	32.35	0.58
T_7	55.54	246.25	151.84	313.04	0.94	14.62	21.16	36.72	0.60
T_8	93.31	252.10	166.60	354.91	1.64	14.59	20.40	36.63	0.59
SEm (±)	9.36	4.38	2.02	16.66	0.17	0.49	0.37	0.46	0.02
CD (P=0.05)	28.24	13.29	6.12	50.52	0.51	1.50	1.12	1.39	0.05

Table 5: Nitrogen use efficiencies of potato as influenced by levels of nitrogen at the end of potato growing season (pooled data of two years)

Treatments	Treatment details	Nitrogen use efficiencies		
		AE_N (kg/kg N applied)	AR_N (kg/kg N applied)	PE_N (kg/kg N applied)
T_1	0 kg N/ha	-	-	-
T_2	50 kg N/ha	106.67	1.03	104.35
T_3	100 kg N/ha	92.44	1.01	91.67
T_4	150 kg N/ha	78.81	0.78	101.58
T_5	200 kg N/ha	85.47	0.71	121.52
T_6	250 kg N/ha	79.79	0.63	127.19
T_7	300 kg N/ha	81.05	0.62	130.90
T_8	350 kg N/ha	69.24	0.51	135.53
SEm (±)		3.83	0.02	4.02
CD (P=0.05)		11.61	0.07	12.19

Table 6: Nutrient uptake of potato as influenced by nitrogen application (pooled data of two years)

Treatment	Treatment details	Total nutrient uptake (Kg/ha)		
		N uptake	P uptake	K uptake
T_1	0 kg N/ha	24.30	9.44	37.35
T_2	50 kg N/ha	75.56	17.14	95.64
T_3	100 kg N/ha	125.35	19.23	110.45
T_4	150 kg N/ha	141.43	22.76	118.90
T_5	200 kg N/ha	165.63	27.48	136.38
T_6	250 kg N/ha	181.60	31.93	138.10
T_7	300 kg N/ha	210.36	36.02	149.12
T_8	350 kg N/ha	203.45	35.81	139.43
SEm (±)		2.54	0.63	3.41
CD (P=0.05)		7.71	1.90	10.33

Table 7: N balance in post-harvest soil as influenced by different N levels at the end of potato growing season (pooled data of two years)

Treatment details	Initial N (kg/ha) (a)	Fertilizer N(kg/ha) (b)	Total N (kg/ha) (c=a+b)	Total N uptake (kg/ha) (d)	Expected balance (kg/ha) (e=c-d)	Actual balance (kg/ha) (f)	Net gain/loss (kg/ha) (f-e)
T_1 (0 kg N/ha)	181.31	0	181.31	24.30	157.01	130.20	-26.81
T_2 (50 kg N/ha)	181.31	50	231.31	75.56	155.75	123.61	-32.14
T_3 (100 kg N /ha)	181.31	100	281.31	125.35	155.96	128.50	-27.45
T_4 (150 kg N/ha)	181.31	150	331.31	141.43	189.88	142.31	-47.57
T_5 (200 kg N/ha)	181.31	200	381.31	165.63	215.68	132.31	-83.37
T_6 (250 kg N/ha)	181.31	250	431.31	181.60	249.71	136.81	-112.90
T_7 (300 kg N/ha)	181.31	300	481.31	210.36	270.95	156.81	-114.14
T_8 (350 kg N/ha)	181.31	350	531.31	203.45	327.86	161.41	-166.45

Table 8: Economics of potato production per ha as influenced by levels of nitrogen (pooled data of two years)

Treatments	Cost of cultivation (Rs/ha)				Yield (t/ha)	Sale price (Rs/t)	Gross return (Rs/ha)	Net returns (Rs/ha)	B: C	ICBR (control basis)	ICBR (RDF basis)
	Seed	Fertilizer	Cultivation	Total							
T_1	48000	20654	73075	141729	12.40	9000	111600	-30129	0.79	-	-
T_2	48000	21296	73075	142371	17.73	9000	159570	17199	1.12	22.90	-
T_3	48000	21938	73075	143013	21.64	9000	194760	51747	1.36	30.39	-
T_4	48000	22580	73075	143655	24.22	9000	217980	74325	1.52	31.48	-
T_5	48000	23223	73075	144298	29.49	9000	265410	121112	1.84	38.25	-
T_6	48000	23865	73075	144940	32.35	9000	291150	146210	2.01	38.50	12.29
T_7	48000	24507	73075	145582	36.72	9000	330480	184898	2.27	41.25	23.78
T_8	48000	25150	73075	146225	36.63	9000	329670	183445	2.26	36.66	19.02

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