



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(7): 774-779
Received: 14-05-2026
Accepted: 18-06-2026

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Assessment of pre-harvest growth indices of potato under different fertilizer regimes

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i7j.6012>

Abstract

A field experiment was conducted to assess the pre-harvest growth indices of potato under different fertilizer regimes having 7 treatments objective of identifying suitable treatment that promote optimum vegetative growth and crop performance for different indices. This experiment analyze the effects of varying fertilizer treatments on important growth parameters like plant height, no. of leaves, no. of shoots, and dry matter accumulation at different growth stages before harvest.

The results indicated that fertilizer application significantly influenced the growth indices. In contrast, inadequate or imbalanced fertilizer application reduced growth rates and biomass accumulation, ultimately affecting crop productivity. The study highlights the importance of balanced fertilizer management in enhancing physiological efficiency and pre-harvest growth of potato. These findings suggest that integrated and recommended fertilizer regimes can improve crop growth dynamics, optimize nutrient use efficiency, and contribute to sustainable potato production.

Keywords: Balanced fertilizer, bulking rate, dry matter accumulation

Introduction

Potato (*Solanum tuberosum* L.) is one of the most important food crops globally and ranks fourth after wheat, rice, and maize in terms of human consumption and production (FAOSTAT, 2023). Owing to its high productivity, wide adaptability, and superior nutritional value, potato plays a vital role in ensuring global food and nutritional security. With the increasing global population and shrinking availability of arable land, the challenge of meeting future food demands while improving farmers' livelihoods has become increasingly significant. Therefore, modern agricultural strategies emphasize the adoption of sustainable production technologies that enhance crop productivity per unit area and per unit time without compromising the long-term productivity of natural resources and ecosystem services.

Potato is also recognized for its excellent nutritional composition. Fresh potato tubers contain approximately 20.6% carbohydrates, 2.1% protein, 0.3% fat, 1.1% crude fibre, and 0.9% ash. In addition, they are a valuable source of vitamin C, several B-complex vitamins, minerals, and essential amino acids, including leucine, tryptophan, and isoleucine. Because of its high energy output per unit area, short crop duration, and balanced nutritional profile, potato has emerged as a strategic crop for enhancing food security, nutritional security, and agricultural sustainability worldwide (FAOSTAT, 2023).

Balanced fertilization is a fundamental component of sustainable agricultural production and has been estimated to contribute nearly 50% of the increase in crop productivity under diverse farming systems. However, continuous cultivation coupled with intensive cropping has resulted in severe depletion of native soil nutrient reserves, reducing the soil's capacity to supply essential nutrients required for sustaining crop productivity and maintaining soil health. In many farming situations, the absence of soil test-based fertilizer recommendations often leads to imbalanced nutrient application, resulting in poor nutrient use efficiency, declining soil fertility, and suboptimal crop yields.

Among the various agronomic factors influencing potato productivity, balanced application of nitrogen (N), phosphorus (P), and potassium (K) plays a crucial role. These primary macronutrients

are considered the most limiting nutrients for potato cultivation in Indian soils. Appropriate fertilization not only enhances tuber yield and quality but also improves nutrient use efficiency and ensures sustainable crop production. Conversely, excessive application of nitrogenous fertilizers, a common practice in intensive agricultural systems, leads to low nitrogen recovery, increased nutrient losses through leaching and volatilization, and the accumulation of reactive nitrogen compounds in the atmosphere, soil, and water bodies, thereby posing serious environmental concerns. Similarly, inadequate availability of phosphorus and potassium remains a major constraint limiting potato productivity in many potato-growing regions. Nitrogen is generally regarded as the first limiting nutrient in potato cultivation because of its profound influence on vegetative growth, canopy development, photosynthetic efficiency, and tuber yield. It is an essential structural component of amino acids, proteins, nucleic acids, chlorophyll, enzymes, and other metabolically active compounds that regulate plant growth and development. Nitrogen deficiency results in stunted plant growth, reduced leaf area, poor root development, and ultimately lower tuber yield. A potato crop producing 25–30 t ha⁻¹ of tubers removes approximately 110 kg N, 50 kg P₂O₅, and 225 kg K₂O per hectare, indicating its exceptionally high nutrient demand, particularly for potassium. Phosphorus plays a central role in plant metabolism by participating in energy transfer, photosynthesis, respiration, cell division, and root development. Adequate phosphorus nutrition promotes early crop establishment, vigorous root growth, and improved tuber initiation, whereas phosphorus deficiency restricts root development and reduces crop productivity. Potassium is the nutrient required in the largest quantity by the potato crop and is often removed from the soil in greater amounts than nitrogen and phosphorus. Potato is considered a potassium-exhaustive crop and serves as an indicator crop for potassium deficiency because of its high K requirement. Potassium regulates numerous physiological and biochemical processes, including enzyme activation, osmotic regulation, stomatal movement, photosynthate translocation, protein synthesis, and starch accumulation in tubers. It also facilitates efficient nitrogen uptake and utilization, thereby improving nutrient use efficiency and enhancing tuber yield and quality. Numerous studies have demonstrated that balanced and judicious application of N, P, and K fertilizers significantly increases potato productivity while maintaining soil fertility and promoting sustainable crop production.

Research Methodology

The present Study was carried out during *rabi* season at the Experimental Farm of Tirhut College of Agriculture, Dholi under the division of Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar. Experimental field was even fertile with uniform textural make up was attached to the main irrigation channel connected to the farm tube well for quick, regular and on-time irrigation. Adequate drainage facility was also provided in order to remove excess water.

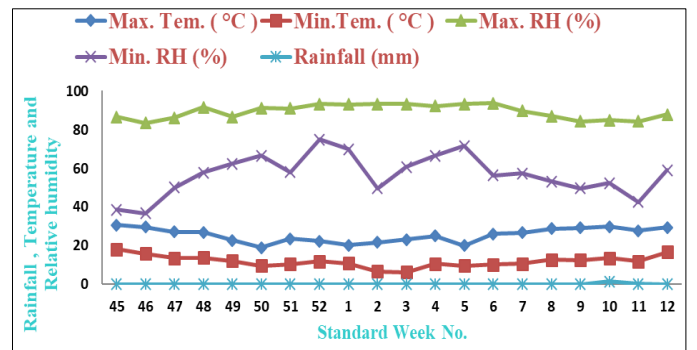
Experimental Soil

The soil of the plot was calcareous alluvial in nature and slight alkaline which developed mainly by the deposition of sediments of the river *Burhi Gandak* over the time. The main characteristic of this soil is the very high content of free calcium carbonate ranging from 10 to 45 percent which is distributed evenly throughout the depth of the profile. The soil of the experimental

plot was Entisol, sandy loam in texture.

Condition of Weather during crop season

Status of the weather condition during the crop season (November to March) weather parameters like maximum and minimum temperature, rainfall (mm), RH (%) presented below:



Weekly meteorological data during crop season

Treatments details	
T ₁	50% Recommended Dose of Fertilizer (RDF) as NPK.
T ₂	100% Recommended Dose of Fertilizer (RDF) as NPK.
T ₃	150% Recommended Dose of Fertilizer (RDF) as NPK.
T ₄	RDF as N [Without N fertilizer (PK)].
T ₅	RDF as P [Without P fertilizer (NK)].
T ₆	RDF as K [Without K fertilizer (NP)].
T ₇	Without NPK(Control).

Layout plan

Season	:	<i>Rabi</i>
Crop	:	Potato
Variety	:	<i>Kufri Ashoka</i>
Design	:	Randomized Complete Block Design (RCBD)
Replication	:	4
No. Treatments	:	7

Sampling plan

Single plot taken as a sampling unit while five plants either appropriate plant number as per requirement per experimental plot as a sample size was taken through simple random sampling technique were adopted. The growth indices of the crop during the experimental year were recorded at regular intervals. The observations recording on 45 DAP than after at appropriate interval based upon crop indices to receive a precise observation of growth analysis.

Pre-harvest studies

Plant emergence (%)

The number of plants emerged were recorded at 30 days after planting. In each row, total emerged plants in each plot were recorded and emergence percent was calculated with the help of the below formula.

Emergence(%) = $\frac{\text{Total numbers of emerged plants}}{\text{Total no. of tubers planted}} \times 100$

Plant height(cm)

The plant height was measured in centimeter from soil surface to the top of growing point of the plant at an interval of 45 DAP, 60 DAP, 75 DAP and at harvest i.e. at haulm. Five representative plants were randomly selected and tagged in each plot to record

for the observation.

Number of shoots (per plant)

The number of shoots per plant were counted from each row for randomly selected each five tagged representative plants at fortnight interval starting from 45DAP, 60DAP, 75 DAP and at harvest.

Per plant number of leaves

The number of leaves per plant were recorded by randomly selected five plants in each and all treatments at an interval of 45 DAP, 60 DAP, 75 DAP and at harvest.

Per plant Dry matter accumulation (gm per plant)

2 plants were randomly selected from sample rows. The tubers and shoots parts were weighed on physical balance followed by cleaning all soils and dust particles present on them. These materials were kept in electric oven for drying at $70^{\circ}\text{C} \pm 1$ until constant weight was obtained. After that it was weight again to obtain dry matter which (g/plant). These observations were recorded in all treatments at an interval of 45DAP, 60DAP, 75 DAP and at harvest.

Bulking rate of tubers (g/day/plant)

Bulking rate were measured in gm/day/plant.

Results and Discussion

Effects of different treatments on pre harvest plant indices in potato.

Plant emergence (%)

The data of plant emergence (%) at 30 days after planting (DAP) which were affected by different treatments are presented in Table 1.

Table 1: Treatment Effects on Plant emergence at 30 DAP

Treatments	Plant emergence (%) at 30 DAP
T ₁ - 50% RDF of NPK	94.18
T ₂ - 100% RDF of NPK	95.40
T ₃ - 150% RDF of NPK	96.59
T ₄ - 100% RDF of P&K	94.19
T ₅ - 100% RDF of N&K	94.54
T ₆ - 100% RDF of N&P	93.83
T ₇ - Control	93.37
S.E.(±m)	1.75
CD(P=0.05)	NS

Per cent plant emergence

The perusal of the data reveals that there were no significant differences among all the treatments at 30 DAP. But treatment T₃ - 150% RDF of NPK (96.59%) had shown maximum per cent plant emergence which was numerically highest over rest of treatments. The lowest plant emergence (93.37%) at 30 DAP was observed in T₇ - Absolute control.

Plant Height (cm)

The observations on plant height recorded at 45, 60, and 75 days after planting (DAP), as well as at harvest, are presented in Table 2. The analysis of variance indicated that fertilizer treatments had a significant effect on plant height at all stages of crop growth.

Plant height at 45 DAP

The data recorded at 45 DAP showed a significant influence of fertilizer treatments on plant height. Among the treatments, T₃

(150% RDF of NPK) produced the tallest plants, recording a mean height of 36.35 cm, which was significantly higher than those obtained under treatments T₁, T₂, T₄, T₅, T₆, and T₇. The lowest plant height (21.12 cm) was observed in T₇ (Absolute Control).

Plant height at 60 DAP

Significant differences in plant height were also observed at 60 DAP due to the application of different fertilizer treatments. The maximum plant height (42.53 cm) was recorded under T₃ (150% RDF of NPK), which was statistically superior to all other treatments. In contrast, the minimum plant height (23.87 cm) was obtained in T₇ (Absolute Control).

Plant height at 75 DAP

At 75 DAP, the effect of fertilizer application remained significant. The highest plant height (49.80 cm) was recorded in T₃ (150% RDF of NPK), whereas T₇ (Absolute Control) registered the lowest value (29.23 cm). The results indicate that higher fertilizer application promoted better vegetative growth during the later stages of crop development.

Plant height at harvest

At harvest, fertilizer treatments continued to show a significant effect on plant height. The tallest plants (49.89 cm) were recorded under T₃ (150% RDF of NPK), which was statistically superior to treatments T₁, T₂, T₄, T₅, T₆, and T₇. The shortest plants (29.23 cm) were observed under T₇ (Absolute Control). These findings suggest that the application of 150% RDF of NPK consistently enhanced plant growth throughout the growing season, whereas the absence of fertilizer resulted in reduced plant height.

Table 2: Plant height (cm) at different growth stages as affected by different treatments

Treatments	Plant height (cm)			
	45 DAP	60 DAP	75 DAP	At harvest
T ₁ - 50% RDF of NPK	25.08	28.20	34.42	34.48
T ₂ - 100% RDF of NPK	30.59	36.98	43.81	43.87
T ₃ - 150% RDF of NPK	36.35	42.53	49.80	49.89
T ₄ - 100% RDF of PK	23.28	26.34	31.53	31.53
T ₅ - 100% RDF of NK	29.89	34.27	41.27	41.30
T ₆ - 100% RDF of NP	29.20	33.75	40.60	40.92
T ₇ - Absolute control	21.12	23.87	29.23	29.23
S.E. (±m)	1.14	1.16	1.52	1.51
CD(P=0.05)	3.43	3.49	4.57	4.56

Number of Shoots per Plant

The observations on the number of shoots per plant recorded at 45, 60, and 75 days after planting (DAP), as well as at harvest, are presented in Table 3. Statistical analysis indicated that the different fertilizer treatments significantly influenced the number of shoots per plant at all stages of crop growth.

Number of shoots per plant at 45 DAP

At 45 DAP, a significant variation in the number of shoots per plant was observed among the fertilizer treatments. The highest number of shoots (5.04) was recorded under T₃ (150% RDF of NPK), which was significantly superior to all other treatments. The lowest number of shoots (2.40) was obtained under T₇ (Absolute Control), indicating poor vegetative development in the absence of fertilizer application.

Number of shoots per plant at 60 DAP

The effect of fertilizer application on shoot production remained

significant at 60 DAP. Treatment T₃ (150% RDF of NPK) produced the maximum number of shoots per plant (6.13), which was significantly higher than the other treatments, including T₂ (100% RDF of NPK), which recorded 5.05 shoots per plant. The minimum number of shoots (3.17) was observed under T₇ (Absolute Control).

Number of shoots per plant at 75 DAP

At 75 DAP, fertilizer treatments continued to exert a significant influence on shoot formation. The highest number of shoots per plant (6.19) was recorded under T₃ (150% RDF of NPK), followed by T₂ (100% RDF of NPK) with 5.08 shoots per plant. The lowest value (3.19) was recorded in T₇ (Absolute Control). These findings indicate that higher fertilizer application enhanced vegetative growth by promoting greater shoot development.

Number of shoots per plant at harvest

A similar trend was observed at harvest. Treatment T₃ (150% RDF of NPK) maintained the highest number of shoots per plant (6.19), which was significantly superior to all other treatments. This was followed by T₂ (100% RDF of NPK) with 5.08 shoots per plant and T₅ (100% RDF of NK) with 4.93 shoots per plant. The lowest number of shoots (3.19) was recorded under T₇ (Absolute Control). The results clearly demonstrate that increasing the fertilizer level up to 150% RDF of NPK markedly improved shoot production, whereas the absence of fertilizer resulted in the lowest shoot count throughout the crop growth period.

Table 3: Number of shoots/plant at different growth stages as affected by different treatments

Treatments	No. of shoots/plant			
	45 DAP	60 DAP	75 DAP	At harvest
T ₁ - 50% RDF of NPK	3.00	3.87	3.92	3.92
T ₂ - 100% RDF of NPK	3.98	5.05	5.08	5.08
T ₃ - 150% RDF of NPK	5.04	6.13	6.19	6.19
T ₄ -100% RDF of PK	2.53	3.41	3.44	3.44
T ₅ - 100% RDF of NK	3.80	4.92	4.93	4.93
T ₆ - 100% RDF of NP	3.45	4.50	4.57	4.57
T ₇ - Absolute control	2.40	3.17	3.19	3.19
SE(±m)	0.08	0.14	0.15	0.15
CD(P=0.05)	0.27	0.44	0.45	0.45

Number of Leaves per Plant

The data on the number of leaves per plant recorded at 45, 60, and 75 days after planting (DAP), as well as at harvest, are presented in Table 4. Statistical analysis revealed that different levels of NPK fertilization significantly affected leaf production at all stages of crop growth.

Number of leaves per plant at 45 DAP

At 45 DAP, the number of leaves per plant varied significantly among the fertilizer treatments. The highest number of leaves (50.50) was recorded under T₃ (150% RDF of NPK), which was significantly superior to all other treatments, namely T₁ (50% RDF of NPK), T₂ (100% RDF of NPK), T₄ (100% RDF of PK), T₅ (100% RDF of NK), T₆ (100% RDF of NP), and T₇ (Absolute Control). The enhanced leaf production under T₃ indicates the positive response of the crop to a higher level of balanced nutrient application.

Number of leaves per plant at 60 DAP

A significant influence of fertilizer treatments on leaf development was also observed at 60 DAP. Treatment T₃ (150%

RDF of NPK) produced the maximum number of leaves per plant (54.75), which was statistically higher than all the remaining treatments. The increase in leaf number under this treatment suggests that an adequate and balanced nutrient supply promoted vigorous vegetative growth.

Number of leaves per plant at 75 DAP

At 75 DAP, the effect of NPK fertilization on leaf production remained significant. The highest number of leaves per plant (59.25) was recorded under T₃ (150% RDF of NPK), whereas the lowest value (37.25) was observed in T₇ (Absolute Control). The results indicate that plants receiving higher levels of NPK maintained greater foliage during the active growth period.

Number of leaves per plant at harvest

At harvest, significant differences in the number of leaves per plant were observed among the treatments. The maximum number of leaves (40.25) was recorded in T₃ (150% RDF of NPK), which was significantly superior to all other treatments. In contrast, T₇ (Absolute Control) recorded the minimum number of leaves (24.50). These findings demonstrate that the application of 150% RDF of NPK sustained better vegetative growth throughout the crop cycle, whereas the absence of fertilizer markedly reduced leaf production.

Table 4: Number of leaves/plant at different growth stages as affected by different treatments

Treatments	Number of leaves/plant			
	45 DAP	60 DAP	75 DAP	At harvest
T ₁ -50% RDF of NPK	34.75	38.50	41.25	26.25
T ₂ - 100% RDF of NPK	41.75	45.25	48.50	31.25
T ₃ - 150% RDF of NPK	50.50	54.75	59.25	40.25
T ₄ -100% RDF of PK	32.25	37.35	39.50	25.25
T ₅ - 100% RDF of NK	40.75	44.75	46.75	30.50
T ₆ - 100% RDF of NP	39.50	43.75	45.75	29.50
T ₇ - Absolute control	31.15	35.25	37.25	24.5
SE(±m)	1.07	1.01	0.90	0.71
CD(P=0.05)	3.23	3.05	2.72	2.14

Dry Matter Accumulation (g plant⁻¹)

The data on dry matter accumulation per plant recorded at 45, 60, and 75 days after planting (DAP), as well as at harvest, are presented in Table 5. Statistical analysis indicated that the different levels of NPK fertilization significantly influenced dry matter accumulation at all stages of crop growth.

Dry matter accumulation at 45 DAP

At 45 DAP, dry matter accumulation varied significantly among the fertilizer treatments. The highest dry matter accumulation (28.68 g plant⁻¹) was recorded under T₃ (150% RDF of NPK), which was significantly superior to all other treatments. In contrast, the lowest dry matter accumulation (16.78 g plant⁻¹) was observed in T₇ (Absolute Control), where no NPK fertilizer was applied.

Dry matter accumulation at 60 DAP

The influence of fertilizer application on dry matter production remained significant at 60 DAP. Treatment T₃ (150% RDF of NPK) recorded the maximum dry matter accumulation (36.36 g plant⁻¹), showing a statistically significant advantage over the remaining treatments. The minimum dry matter accumulation (22.51 g plant⁻¹) was recorded under T₇ (Absolute Control).

Dry matter accumulation at 75 DAP

At 75 DAP, significant differences in dry matter accumulation

were observed among the treatments. The highest dry matter accumulation ($60.80 \text{ g plant}^{-1}$) was obtained with T_3 (150% RDF of NPK), which was significantly superior to all other treatments. The lowest value ($31.70 \text{ g plant}^{-1}$) was recorded in T_7 (Absolute Control). These results indicate that increased NPK application enhanced biomass production during the active growth phase.

Dry matter accumulation at harvest

At harvest, fertilizer treatments continued to have a significant effect on dry matter accumulation. The maximum dry matter accumulation ($70.80 \text{ g plant}^{-1}$) was recorded under T_3 (150% RDF of NPK), which was statistically superior to the other treatments. The lowest dry matter accumulation ($45.61 \text{ g plant}^{-1}$) was observed in T_7 (Absolute Control). The results demonstrate that the application of 150% RDF of NPK promoted greater biomass accumulation throughout the crop growth period, whereas the absence of fertilizer resulted in the lowest dry matter production.

Table 5: Dry matter accumulation (g/plant) at different growth stages as affected by different treatments

Treatments	Dry matter accumulation (g/plant)			
	45 DAP	60 DAP	75 DAP	At harvest
T_1 -50% RDF of NPK	21.17	26.67	42.20	53.60
T_2 - 100% RDF of NPK	25.60	32.63	50.29	61.86
T_3 - 150% RDF of NPK	28.68	36.36	60.80	70.80
T_4 -100% RDF of PK	19.02	23.89	33.49	46.89
T_5 - 100% RDF of NK	24.33	31.36	49.78	60.37
T_6 - 100% RDF of NP	23.24	30.65	46.19	59.03
T_7 - Absolute control	16.78	22.51	31.70	45.61
SEm $\pm$	0.94	1.30	2.93	2.44
CD(P=0.05)	2.84	3.91	8.79	7.33

Bulking Rate ($\text{g plant}^{-1} \text{ day}^{-1}$)

The data on tuber bulking rate during the growth periods of 45–60 DAP, 60–75 DAP, and 75 DAP to harvest under different NPK fertilizer treatments are presented in Table 6. The statistical analysis revealed that NPK application had a significant effect on the bulking rate of potato at all growth intervals.

Bulking rate during 45–60 DAP

Significant differences in tuber bulking rate were observed among the fertilizer treatments during the 45–60 DAP growth period. The highest bulking rate ($9.14 \text{ g plant}^{-1} \text{ day}^{-1}$) was recorded under T_3 (150% RDF of NPK), which was statistically superior to all other treatments. The lowest bulking rate ($4.10 \text{ g plant}^{-1} \text{ day}^{-1}$) was observed in T_7 (Absolute Control), indicating reduced tuber growth under nutrient-deficient conditions.

Bulking rate during 60–75 DAP

During the 60–75 DAP interval, fertilizer treatments continued to exert a significant influence on tuber bulking. The maximum bulking rate ($10.06 \text{ g plant}^{-1} \text{ day}^{-1}$) was recorded under T_3 (150% RDF of NPK), which was significantly higher than all other treatments. This stage exhibited the highest bulking rate among all growth periods, reflecting the period of maximum tuber development. In contrast, the minimum bulking rate ($4.55 \text{ g plant}^{-1} \text{ day}^{-1}$) was recorded under T_7 (Absolute Control).

Bulking rate from 75 DAP to harvest

The bulking rate declined during the final growth stage (75 DAP to harvest), although significant differences among the fertilizer treatments were still evident. Treatment T_3 (150% RDF of NPK) recorded the highest bulking rate ($2.75 \text{ g plant}^{-1} \text{ day}^{-1}$), which was significantly superior to all other treatments. The reduced bulking

rate during this stage indicates that tuber growth slowed as the crop approached physiological maturity. Overall, the results demonstrate that the application of 150% RDF of NPK consistently promoted higher tuber bulking throughout the crop growth period.

Table 6: Bulking rate (g/day/plant) at different growth stages as affected by different treatments

Treatments	Bulking rate (g/day/plant)		
	45-60 DAP	60-75 DAP	75 DAP – harvest
T_1 -50% RDF of NPK	5.29	5.95	1.84
T_2 - 100% RDF of NPK	7.32	8.29	2.23
T_3 - 150% RDF of NPK	9.14	10.06	2.75
T_4 -100% RDF of PK	4.31	4.87	1.63
T_5 - 100% RDF of NK	6.18	7.36	2.12
T_6 - 100% RDF of NP	6.02	7.08	2.075
T_7 - Absolute control	4.10	4.55	1.45
S.E.($\pm$ m)	0.38	0.45	0.07
CD(P=0.05)	1.16	1.37	0.23

Conclusion

The present investigation evaluated the influence of different levels of nitrogen, phosphorus, and potassium (NPK) fertilizers on the pre-harvest growth parameters of potato. The growth characteristics studied included percentage emergence, plant height, number of shoots per plant, number of leaves per plant, dry matter accumulation, and tuber bulking rate.

Percentage plant emergence

The percentage of plant emergence recorded at 30 days after planting (DAP) did not differ significantly among the fertilizer treatments, indicating that varying NPK levels had no measurable effect on crop emergence.

Plant height

Plant height was significantly affected by the fertilizer treatments at all growth stages (45, 60, and 75 DAP, and at harvest). The highest plant height (49.89 cm) was recorded under T_3 (150% RDF of NPK), followed by T_2 (100% RDF of NPK). Both treatments performed better than the remaining fertilizer treatments. The shortest plants (29.23 cm) were observed under T_7 (Absolute Control), where no NPK fertilizer was applied.

Number of shoots per plant

The application of NPK fertilizers significantly influenced shoot production. Treatment T_3 (150% RDF of NPK) produced the highest number of shoots per plant (6.19) at 60 DAP, 75 DAP, and harvest, while the lowest number of shoots (3.19) was recorded in T_7 (Absolute Control).

Number of leaves per plant

The number of leaves per plant increased significantly with increasing fertilizer levels. The maximum number of leaves (59.25) was recorded under T_3 (150% RDF of NPK) at 75 DAP, whereas the minimum number of leaves (37.25) was observed in T_7 (Absolute Control).

Dry matter accumulation

Dry matter accumulation was significantly influenced by NPK fertilization throughout the crop growth period. The highest dry matter accumulation ($70.80 \text{ g plant}^{-1}$) was obtained under T_3 (150% RDF of NPK) at harvest. Lower dry matter production was recorded in treatments with nutrient omission and was the lowest in T_7 (Absolute Control), demonstrating the importance of

balanced nutrient application for biomass production.

Bulking rate

Tuber bulking rate varied significantly among the fertilizer treatments. The maximum bulking rate ($10.06 \text{ g plant}^{-1} \text{ day}^{-1}$) was recorded under T_3 (150% RDF of NPK), followed by T_2 (100% RDF of NPK) with $8.29 \text{ g plant}^{-1} \text{ day}^{-1}$. The minimum bulking rate ($4.55 \text{ g plant}^{-1} \text{ day}^{-1}$) was observed under T_7 (Absolute Control).

Overall, the results of the study indicate that the application of 150% RDF of NPK (T_3) consistently produced superior growth performance compared with the other fertilizer treatments. This treatment resulted in greater plant height, higher numbers of shoots and leaves, increased dry matter accumulation, and a higher tuber bulking rate. Therefore, under the conditions of the present study, 150% RDF of NPK proved to be the most effective fertilizer regime for enhancing the pre-harvest growth and development of potato.

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