

**Impact of varying nitrogen levels on growth, yield and economics
of different varieties of potato (*Solanum tuberosum* L.)
in the foothills of Uttarakhand**

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ABSTRACT

This study was carried out at the Gaulapar farm (Haldwani), district-Nainital, Uttarakhand, during the Rabi season of 2022–2023. To find out the impact of varying nitrogen levels on the growth, yield, and economics of different varieties of potato in a split plot design (SPD) with twelve treatment combinations were reproduced three times, with four varieties of potato (V₁-Kufri Badshah, V₂-Kufri Sindhuri, V₃-Kufri Chandramukhi, and V₄-Gola) and three nitrogen levels (N₁-100%, N₂-125%, and N₃-150%). Fertilizer treatment was kept in main plot and varieties in sub-plot. Variety Kufri Sindhuri recorded higher plant height, number of tubers per plant, and number of branches, and in variety Kufri Chandramukhi, the highest yield and economics were recorded. Interaction between varieties and fertilizers were recorded. At every stage of growth, the quantity of tubers and weight were considerably higher when nitrogen 150% (N₃) was applied. It was discovered that the best way to increase the yield of tubers per plot was obtained when 150% nitrogen applied in the field. The findings showed that Kufri Chandramukhi (V₃) with 150% N₃ produced the highest gross return (Rs. 544000/ha), net return (Rs. 357757/ha), and benefit-cost ratio (Rs. 2).

Keywords: - *Solanum tuberosum* L., Nitrogen fertilizer, Varieties, Growth, Yield and economics.

INTRODUCTION

One of the most important vegetable crops i.e. potatoes (*Solanum tuberosum* L.) most likely originated in South America. It has the potential to replace cereals that are meant for human consumption to a larger extent. This vegetable is a rich source of carbohydrates, contains protein, and is utilized in various industrial applications. Depending on the climate, potatoes can be cultivated both in the winter and during the rainy season. India is second in the world's potato production rankings, behind China, with an annual production of between 50 and 55 million tons. The states in India that cultivate potatoes include Bihar, Karnataka, Uttar Pradesh (UP), Madhya Pradesh (MP), and West Bengal. In the fiscal year 2023, the estimated production of potatoes in India was approximately 59.74 million metric tons. The cultivation area available to produce potatoes across India during the year 2023 is estimated to be approximately 2.35 million hectares, and production is expected to be around 59.74 million metric tons. (National Horticulture Board, 2022). The nutrient demands of potato crops are significantly high, and the use of fertilizers and organic manures is deemed crucial for achieving optimal economic yields. Nitrogen is the primary limiting factor for potato cultivation; it enhances vegetative growth and increases the number of tubers per plant (Bhomik and Dandapat, 1991), as well as the size of the tubers (Anand and Krishnappa, 1988). Rapid availability of nitrogen in the soil boosts root development. It is essential for nitrogen to be sufficiently present in the soil at planting time to promote root growth in the seed tuber. The application of nitrogen consistently leads to higher yields (Pushkarnath, 1976). Potato plants that receive adequate nitrogen exhibit robust growth, increased leaf area, larger tubers, and a greater tuber count. Nitrogen is the primary nutrient needed for potato cultivation, and there is significant variation in nitrogen needs among different cultivars (Chare et al., 1990). Generally, as nitrogen application rates increase, cultivars tend to produce higher yields (Belanger *et al.*, 2000; Arsenault *et al.*, 2001). Nevertheless, applying too much nitrogen can result in poor-

quality tubers, delayed maturity of the crop, and increased nitrate leaching, while a lack of nitrogen typically leads to suboptimal growth and reduced yields (Harris, 1992). Nitrogen response depends on soil, cultivars, length of growing season, organic fertilizers, manures, time and method of application, moisture availability, and the interaction of nutrients with crop nitrogen requirements. Long-duration potato varieties such as Kufri Badshah, Kufri Lalima, and Kufri Sinduri, which produce large tubers, respond better to nitrogen than short-duration potato varieties that produce small and medium-sized tubers. Potatoes require nitrogen from the time they germinate until they reach full maturity. The demand for this nutrient increases significantly after germination and begins to decrease once 75 percent of the plant's growth has been achieved. Understanding the ideal nitrogen levels for potato crops in various agroclimatic conditions is essential for effective fertilizer use and maximizing yields. Analysis of fertilizers produced by the regional centers of the Central Institute of Potatoes in recent years has indicated that potatoes consistently respond well to inorganic nitrogen, phosphorus, and potassium chloride. Therefore, it was deemed appropriate to initiate research on the nitrogen needs of plants grown from seed tubers, as nitrogen plays a crucial role in this crop's development.

MATERIALS AND METHODS

The present experiment was conducted during the Rabi season of 2021-2022 in the Gaulapar (Haldwani), Nainital, Uttarakhand. The experimental site is in the foothills of the Himalayas. Gaulapar is a village area that is located in Haldwani tehsil. Gaulapar soil is rich in calcium and has a pH range of 6-6.5. The experimental material for the study was laid out in a split plot design (SPD), which consists of 4 genotypes of potato, i.e., Gola, Kufri Chandramukhi, Kufri Sindhuri, and Kufri Badshah. Sixteen treatments comprised four dates of sowing. A split-plot design with three replications was utilized to organize four different varieties. The main plots contained the fertilizer treatments, while the varieties were

arranged in the subplots. The variety Gola was used for the experiment as it is the locally available variety, which is cultivated broadly, and it has got higher market value in the foothills of Himalayas. Kufri Badshah, Kufri Chandramukhi and Kufri Sinduri were included in the experiment because they are released specifically for North Indian Plains. These varieties possess resistance against blights and potato virus x specially Kufri Badshah.

For planting, uniformly sized tubers weighing 30–50 g of the varieties V₁-Kufri Badshah, V₂-Kufri Sindhuri, V₃-Kufri Chandramukhi, and V₄-Gola were selected. To remove fungal infections, seed tubers were treated with a 0.2% solution of Indofil M-45 for ten minutes. They were then allowed to dry in the shade before being planted. On the line directly next to the fertilizer furrow, tubers were planted with a 20 cm plant spacing and a 60 cm row spacing. While nitrogen was applied in split doses to each plot based on treatments, phosphorus and potassium were applied in full doses of 100 kg/ha through a single superphosphate and potassium as a basal dose at planting. As a base dressing, urea was used to apply half of each treatment's nitrogen rate; the remaining half was administered 30 days following planting. Prior to the tubers being planted, the three fertilizers that made up the base fertilizer were combined and applied in the middle of the ridges. Just before planting, the leftover nitrogenase was used as a surface treatment after 30 days of planting. Using irrigation channels, irrigation was carried out. Before planting, a preliminary irrigation was carried out to give the soil the right amount of moisture, which promotes seed germination. The second irrigation was applied to each plot on November 24, 2022, and the third irrigation was applied on December 27, 2022. Following the urea top dressing, earthing up was carried out. Furrows were turned into ridges up to 20 cm high by hand, using a shovel, at 30 and 60 days following planting. With Khurpi's assistance, the plot was hand-weeded during the earthing-up process. Hand weeding was also done on the first, third, fifth, and seventh days, and often after a period of one to two weeks. Twenty days after

planting, or December 22, 2022, and twenty days after earthing up, or December 25, 2022, the remaining half dose of nitrogen was sprayed in two equal splits. One application of Indofil M-45 (2.5 g/liter of water) was made at 40 DAP, and another application of Ridomil (2.5 g/liter of water) was made at 50 DAP for controlling blight. During the final week of January, 0.5 ml/liter of water was sprayed with imidacloprid to suppress aphids. With the aid of a khurpi, harvesting was carried out by hand. Potato tubers were gathered plot by plot and subsequently graded according to size, quality, color, and other factors; defective tubers were separated from the healthy ones. Haulm cutting and dehauling were completed on 14/1/2023 (75DAP). Haulms were removed from the bottom, leaving the remaining area underneath. Various economic, growth, and yield metrics were used. Growth parameters include the number of shoots per plant, height of the plant 30 and 60 days after planting, and emergence after 30 days. Yield parameters include the number of tubers per plant, the number of defective tubers, the weight of the tubers per plant (kg/plot), the yield per plot (kg/ha), the yield per hectare, and the economics parameter.

RESULTS AND DISCUSSION

Growth attributing character

Plant height (30 and 60 days after planting, in centimeters), number of shoots per plant, and emergence 15 days after planting are the observations examined under growth-attributing traits.

Emergence at 30 DAP (%):

The percentage of plant emergence at 30 DAP was not impacted by treatment; Kufri Sindhuri (V₂) had the highest percentage of emergence (85.683), followed by Kufri Chandramukhi (V₃) (85.587), Kufri Badshah (V₁) (84.813), and Gola (V₄) (84.250). Of the various nitrogen levels, Kufri Sindhuri (V₂) is comparable to Kufri Chandramukhi (V₃), which exhibits a noticeably greater percent emergence (86.478) in 150% (N₃), which was statistically equivalent to 125% (N₂).

Effect of different levels of nitrogen on plant height (cm):

The variety Kufri Badshah (V1) had the highest plant height, followed by Gola (V4), Kufri Sindhuri (V2), and Kufri Chandramukhi (V3) at 30DAP (38.267, 37.903, 34.440, and 33.903 cm respectively), and Kufri Sindhuri (V2) followed by Kufri Chandramukhi (V3), Kufri Badshah (V1), and Gola (V4) at 60DAP (47.270, 41.747, 41.284, and 39.247 cm respectively). This was found to be significantly better than all the varieties in this study. Variety Kufri Chandramukhi (V3) at 30DAP and Gola (V4) at 60DAP showed the smallest plant heights. With regard to nitrogen levels, it was shown that when nitrogen levels rose, plant height grew gradually.

Table: 1 Effect of varieties and fertilizers on emergence 15 DAP, plant height 30 & 60 DAP, and number of branches per plant.

At all plant growth phases, noticeably taller plants were seen at 150% N (N3).

Number of branches/plant:

Kufri Sindhuri (V2) (5.967) was the variety with the highest number of branches, followed by Kufri Chandramukhi (V3) (5.217), Kufri Badshah (V2) (4.383), and Gola (V4) (4.717). There was a noticeable difference in the number of plant branches depending on the nitrogen level. 150 percent nitrogen (N3) had the most branches, followed by 125% nitrogen (N2) and 100% nitrogen (N1).

Treatments	Emergence 30 DAP	Plant height (30 cm DAP)	Plant height (60 cm DAP)	Number of branches per plant
Mean value for factor A				
Kufri Badshah (V1)	84.813	38.267	41.284	4.383
Kufri Sindhuri (V2)	85.683	34.440	47.270	5.967
Kufri Chandramukhi (V3)	85.587	33.903	41.747	5.217
Gola (V4)	84.250	37.903	39.247	4.717
S.Em ±	0.033	0.002	0.007	0.001
C.D at 5%	0.097	0.006	0.021	0.004
Mean value for factor B				
Treatments (Nitrogen levels)				
100%(N1) (150KgN/ha)	83.221	35.522	40.453	4.529
125%(N2) (187.5KgN/ha)	85.551	36.177	41.577	4.967
150%(N3) (225KgN/ha)	86.478	36.687	45.132	5.717
S.Em ±	0.028	0.002	0.018	0.001
C.D at 5%	0.084	0.005	0.006	0.003

Number of tubers per plant:

Kufri Sindhuri (V2) (9.297) was the variety that produced the most tubers per plant, according to the data. Kufri Badshah (V1) (8.353), Gola (V4) (7.490), and Kufri Chandramukhi (V3) (6.260) were next in line. Among the various nitrogen concentrations analyzed in this study, 150%N (N3) produced the most tubers per plant, whereas 100% N (N1) produced the fewest tubers per plant.

Nitrogen on defected tubers: -

The data showed that the variety Kufri Sindhuri (V2) (1.422) produced significantly higher defected

tubers followed by Kufri Badshah (V1) (1.400), Gola (V4) (1.400) and Kufri Chandramukhi (V3) (1.367). Among the various nitrogen concentrations analyzed in this study, 150%N (N3) produced the most tubers per plant, whereas 100% N (N1) produced the fewest tubers per plant.

Weight of tuber per plant:

Among the different varieties of potato, Kufri Sindhuri (V2) (237.207 kg) recorded the significantly higher weight of potato tubers followed by Gola (V4), Kufri Badshah (V1) and Kufri Chandramukhi (V3). When nitrogen levels varied, the amount of tubers per plant that weighed the most was 150 percent N (N3), followed by 125% N (N2) and 100% N (N1).

Yield per plot (kg/plot):

In contrast to the other varieties, Kufri Chandramukhi (V3) produced a higher tuber yield (23.647 kg/plot). The variety known as Kufri Badshah (V1) produced the least amount of tubers (17.343 kg/plot). Different nitrogen levels revealed that the nitrogen level under 150% N (N3) produced a greater tuber yield (21.832 kg/plot), which was determined to be substantially better than 125% N (N2) and 100% N (N1).

Nitrogen on yield (t/ha):

Compared to the other varieties, Kufri Chandramukhi (V3) had a noticeably higher tuber yield (27.1973 t/ha). In comparison to the variations Kufri Sindhuri (V2) and Kufri Badshah (V1), variety Gola (V4) also showed a considerably greater total tuber yield (23.5633 t/ha). This could be because the tubers were larger and heavier. When nitrogen levels varied, the treatment with 150% N (N3) produced a much larger tuber yield than the treatments with 125% N (N2) and 100% N (N1).

Table: 2 Effect of varieties and fertilizers on the number of tubers per plant, number of defected tubers, weight of tuber, tuber yield per plot, tuber yield tonnes/ha.

Treatments	Number tubers per plant	Number defected tubers	Weight of Tuber/plant (Kg)	Tuber yield per plot (Kg/plot)	Tuber yield (tonnes/ha)
Mean value for factor A					
Kufri Badshah (V1)	8.353	1.400	169.263	17.343	18.91
Kufri Sindhuri (V2)	9.297	1.422	237.207	19.943	20.8189
Kufri Chandramukhi (V3)	6.260	1.367	169.013	23.647	27.1973
Gola (V4)	7.490	1.400	183.680	21.560	23.5633
S.Em ±	0.035	0.1415	0.015	0.004	0.037
C.D at 5%	0.103	N.S	0.045	0.011	0.109
Mean value for factor B					
Treatments (Nitrogen levels)					
100%(N1) (150KgN/ha)	6.792	1.000	184.305	16.697	21.9589
125%(N2) (187.5KgN/ha)	7.864	1.342	189.930	20.342	22.2681
150%(N3) (225KgN/ha)	8.894	1.850	195.138	21.832	23.6402
S.Em ±	0.030	0.1042	0.013	0.003	0.032
C.D at 5%	0.090	0.3124	0.039	0.009	0.094

CONCLUSION

It was discovered that Kufri Chandramukhi (V3) had the highest tuber yield of the four tested types. Based on yield and economic analysis, N3 (150% N) was determined to be the most appropriate of the three nitrogen levels examined, as opposed to N2 (125% N) and N1

(100% N). Thus, it can be concluded that, in comparison to the other nitrogen levels, namely N2 (125% N) and N1 (100% N), the production of potatoes in the study region of Gaulapar, Haldwani (Uttarakhand), using nitrogen levels N3 (150% N) is relatively greater and more cost-effective.

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