

Effect of integrated nutrient management on growth, yield and quality of potato (*Solanum tuberosum* L.)

Abstract

A field experiment was conducted at Instructional farm, DCAAS College Rampur, Dehradun, Uttarakhand, during the Rabi season of 2022-2023 to evaluate the performance of potato under different integrated nutrient management (INM) options. The experiment was placed in randomised block design (RBD) with five nutrient management options. Various parameters related to plant growth, tuber formation, and tuber weight and yield were examined across different treatment conditions. The results revealed that T₅ (Vermicompost + Urea + FYM + Neemcake), representing an integrated nutrient management approach, consistently exhibited the highest plant weight (23.633cm) at different growth stages (30 DAS, 60 DAS, 90 DAS), indicating a positive effect on plant growth. Additionally, T₃(Urea) displayed superior performance regarding the number of tubers in different weight categories (0-25g, 25-50g, 50-75g, and 75g), suggesting enhanced tuber formation. However, the most significant outcome was the consistent superiority of T₅ in terms of tuber weight and yield. T₅ consistently produced the highest weight of tubers in all weight categories and achieved the highest tuber yield per plot (9.243q h⁻¹). These findings underscore the positive impact of integrated nutrient management practices on tuber weight and overall crop productivity in potatoes. It is important to note that specific details regarding the nutrient management practices used were not provided, necessitating further research to identify the particular combination and types of nutrients employed in T₅. Overall, this study emphasizes the importance of implementing integrated nutrient management strategies to enhance the growth and yield of potato crops, encouraging further investigation into the optimization of plant growth and tuber yield through nutrient management practices.

Keywords: Integrated nutrient management, treatment, growth parameters.

Introduction

Solanum tuberosum L., commonly known as Potato, is indigenous to South America and is the predominant vegetable crop globally, occupying the largest cultivation area. Currently, over 46% of the world's potato production originates from developing Asian countries. This surge underscores its escalating significance as a vital food source for

burgeoning populations, contributing to rural employment and income generation. As the fourth most-consumed food crop worldwide, following rice, wheat, and maize, the Potato boasts high nutritional content (carbohydrates, proteins, dietary fibre, vitamins, minerals, amino acids, etc.), easy digestibility, and substantial yield (<https://www.cgiar.org/research/center/cip/>). Widely acknowledged as the "poor man's friend," the Potato consistently assures cost-effective energy and nutritional sustenance across diverse economic strata. India ranks second globally in potato production, with China leading the charts. In 2018-19, India cultivated potatoes on an average of over 2.18 million hectares, yielding 52.58 million tonnes, with a productivity of 24.07 tonnes/ha (<https://agriwelfare.gov.in/en/Horticulturereports>, 2020). Potato cultivation in India is primarily concentrated in the northern hills and plains, eastern hills, plateau regions, and southern hills, with Uttar Pradesh and West Bengal emerging as the leading states in potato cultivation. Other significant potato-producing states include Bihar, Madhya Pradesh, Assam, Gujarat, Punjab, Jharkhand, Karnataka, Haryana, and Chhattisgarh (<https://agriwelfare.gov.in/en/Horticulturereports>, 2020).

The versatility of potatoes finds expression in various forms for table consumption, including its role as a vegetable ingredient in cooked dishes and the production of potato flour for snacks, chips, slices, shredded potatoes, mashed potatoes, and French fries. Additionally, potatoes hold industrial value in the output of dextrin, alcohol, and starch, particularly farina, used in laundries and textiles. The nutrient demands of potatoes are high due to their relatively underdeveloped and shallow root system, resulting in a significant extraction of nutrients from the soil (Sarkar *et al.*, 2011). To ensure sustainable productivity and maintain soil health, an integrated approach to nutrient supply using organic, inorganic, and bio-fertilizers is imperative (Jagadeesh *et al.*, 1994). Farm Yard Manure (FYM) emerges as valuable organic manure, not only for its nutrient content but also for its contribution to soil improvement, aeration, water retention, and stimulation of microbial activity. Combining chemical fertilizers with organic manures, such as farm yard manure, compost, vermin-compost, bio-fertilizers, micronutrients, and other materials, is universally recognized for its beneficial effects (Alam *et al.*, 2007 & Chettri *et al.*, 2005). A balanced integration of organic and inorganic fertilizers and bio-fertilizers represents an ideal strategy to meet nutrient requirements for most vegetable crops (Yawalker *et al.*, 1996). Adopting integrated nutrient management practices is essential for realizing higher yields, improved quality, and enhanced returns in vegetable crop cultivation.

Material and methods

The present investigation focused on optimizing potato yield in the Horticulture field of DCAAS College Rampur, Dehradun, Uttarakhand, during the Rabi season of 2022-2023. The experiment employs the "*Kufri Chandramukhi*" variety of potatoes and utilizes a Randomized Block Design (RBD) to investigate the impact of different treatments on crop performance. The study involves 20 plots with a spacing of rows 30cm x 30cm; individual plot size was 5m x 5m, organized into five treatments (T1-Control, T2-Vermi Compost, T3-Urea, T4-Urea+Neemcake, T5-vermicompost + Urea + FYM + Neemcake), 125kg Urea, 20 ton FYM, 5-ton Vermicompost and 3-ton Neem Cake ha⁻¹ brought paramount of improvement in growth and tuber yield of potato. Each replicated thrice. The experiment commenced with the sowing of potatoes on November 1st, 2022. The aim is to contribute valuable insights into potato cultivation practices, enhancing agricultural productivity and sustainability.

Experimental site and location

The experiment site is located 29 km away from Dehradun city at the elevation of North latitude of 29°58' to 31°2' and east longitude of 77°34' to 78°18' and altitude of 1467ft above the mean sea level.

Climate and weather condition

The climate of this area is sub - temperate to sub - tropical with hot desiccating summers and cold winters. The maximum temperature exceeds even 45 °C during the hot summers and minimum temperature occasionally plummeted to 1°C during winters. High rainfall 138(cm/annum) and wide temperature fluctuations are silent features of tarai generally monsoon sets in the third to fourth week of June and continues up to September. The data (2022-2023) on weather conditions that prevailed during crop season recorded at the meteorological observatory located at the F.R.I. station. The weekly mean maximum and minimum temperature during the crop season ranges from 28.27 °C to 14.83°C and 9.75°C to 0.81°C, respectively. The weekly ranged relative humidity ranged from 97% (max.) at 7:00 am and 43% (min.) at 2:00 pm (Table 1). The total amount of rainfall received during crop season was 500mm and which was distributed up to February.

Table 1. Meteorological data observed during period of experiment from 1st November, 2022 to 4th February 2023

Date and Month	Mean temperature(°C)		Relative Humidity(%)		Rainfall(mm)
	Max.	Min.	Morning	Evening	
1 Nov to 6 Nov	28.27	9.11	94.64	46.27	0
7 Nov to 12 Nov	27.51	9.31	92.98	44.31	0
13 Nov to 18 Nov	27.17	7.76	92.72	47.49	0
19 Nov to 24 Nov	26.36	6.83	93.17	45.28	0
25 Nov to 30 Nov	24.81	5.87	95.72	46.28	0
1 Dec to 6 Dec	21.89	9.75	95.46	65.01	0.37
7 Dec to 12 Dec	23.02	4.87	94.27	44.88	0
13 Dec to 18 Dec	21.29	0.87	94.27	43.63	0
19 Dec to 24 Dec	19.38	0.81	94.78	45.10	0
25 Dec to 30 Dec	20.48	1.81	95.98	52.11	0
31 Dec to 5 Jan	19.69	2.35	95.81	45.80	0
6 Jan to 11 Jan	18.70	6.79	97.13	65.95	21.72
12 Jan to 17 Jan	19	8.55	93.18	61.37	0
18 Jan to 23 Jan	18.61	9.01	91.62	69.01	0
24 Jan to 29 Jan	14.93	7.72	96.75	62.13	0.6597
30 Jan to 4 Feb	18.32	5.93	95.30	58.48	0
Total	349.43	97.34	1513.78	843.1	22.749
Average	21.844	6.06342	94.59779	52.69845	1.421856

Soil of the experimental field

The soil was well irrigated, well treated before the sowing of tubers. The soil was alluvial in experimental field that has the sandy, clayey and rocky elements.

Nursery preparation

A bed size of 1.25m x 3m was prepared after proper hoeing and weeding. The bed was kept raised 15 cm above the ground level so as to provide proper drainage of excess

water. Well rotten FYM was mixed in the nursery bed and seeds were sown on 16/10/2022 in the nursery beds with lines 5 cm apart and 2-3 cm deep. The opened rows were closed with the mixture of FYM, soil and sand. The surface was watered with a fine rose-can. After seed germination, watering was done in the nursery bed at weekly interval or as and when required

Table 2: Composition of organic sources

Name of manure	Nitrogen %	Phosphorus %	Potash %
FYM	0.5	0.25	0.5
Vermi-compost	2.0	0.3	0.7

Planting of tubers

Seed was treated with PSB @ 10 ml L⁻¹ done at before planting. Seed was planted @ 25-30 q ha⁻¹ by manually at a uniform distance of sixty centimetres between row to row and twenty centimetres distance between plant to plant.

Statistical analysis

All data related to crop collected were statistically analyzed by using the analysis of variance technique (Fisher, 1958) through R software. Data computed was subjected to Fisher's analysis of variance for judging the effect of various treatments.

Comparison of mean corresponding to different significant effect was made by using critical difference at 5% level of significance.

Ve = Error M.S. r = Replications

The standard error of the means of different treatments has been calculated with the following formula:

$$SEM_{\pm} = \sqrt{\frac{ErrorMS}{r(4)}}$$

Note: DF= Degree of freedom

SS= Sum of square

MS= Mean sum of Square

Critical difference (CD)

CD= $SEM_{\pm} \times \sqrt{2} \times t$ value for error degree of freedom (14) at 5% level of significance.

Results and Discussions

Effect of INM on growth parameters of potato

Plant growth parameters were meticulously evaluated in the potato cultivation of the Horticulture field at DCAAS College Rampur, U.K., during the Rabi season of 2022-2023. Measurements included plant height (cm), number of haulms per meter, number of leaves per meter, fresh weight of haulm, and dry weight of haulm. Plant height data, obtained at 30, 60, and 90 Days after Planting (DAP), revealed substantial differences among treatments across all growth stages. At 30 DAP, treatment 5 exhibited the highest plant height (23.633 cm), followed sequentially by treatments 4, 3, 2, and 1. This trend persisted at 60 DAP and 90 DAP, with treatment 5 consistently surpassing other treatments. The analysis of haulm density (number of haulms demonstrated treatment 4's predominance at 30 DAP (7.532), succeeded by treatments 5, 1, 2, and 3. At 60 DAP, treatment 5 displayed the highest haulm density (34.533), followed by treatment 4, 2, 1, and 3. At 90 DAP (Hassan *et al.*, 2017), treatment 4 maintained superiority (34.613), followed by treatments 2, 5, 3, and 1 (Choudhary *et al.*, 2010). Concurrently, leaf counts (number of leaves were significantly influenced by integrated nutrient management practices. At all observation stages, treatment 5 consistently exhibited the highest leaf numbers. Lastly, fresh weight and dry weight of haulms at the dehaulming stage were significantly impacted by the applied nutrient management practices. Treatment 5 displayed superior fresh weight (370.14gm) and dry weight (37.39 gm), maintaining a consistent trend across all observed parameters (Table 3 and Figure 1). These findings underscore the efficacy of Treatment 5 in promoting robust growth across multiple facets of potato cultivation.

Table 3: Effect of integrated nutrient management (INM) on growth parameters of potato

Treatments	Plant weight			No of haulms			No of leaves			Fresh weight haulm	Dry weight
	30 DAS	60DAS	90 DAS	30 DAS	60DAS	90 DAS	30 DAS	60DAS	90 DAS		
1	17.96	41.067	43.146	7.309	33.893	34.577	65.175	291.69	304.044	356.37	33.687
2	22.167	42.837	43.481	7.306	34.347	34.273	65.177	291.75	304.037	358.57	34.443
3	21.977	43.923	45.417	7.272	33.38	34.54	64.517	297.05	305.393	360.407	34.56
4	22.85	44.297	44.442	7.532	34.264	34.613	66.117	296.513	307.457	365.437	35.803
5	23.633	44.61	45.455	7.364	34.533	34.477	66.683	297.617	307.653	370.14	37.39
C.D.	1.582	1.28	0.57	0.061	0.33	0.31	1.536	1.417	2.233	1.572	0.989
SE(m)	0.478	0.387	0.172	0.019	0.1	0.193	0.464	0.428	0.674	0.475	0.299
SE(d)	0.675	0.547	0.244	0.026	0.141	0.273	0.656	0.605	0.953	0.671	0.422
C.V.	3.809	1.545	0.672	0.437	0.507	0.968	1.23	0.251	0.383	0.227	1.47

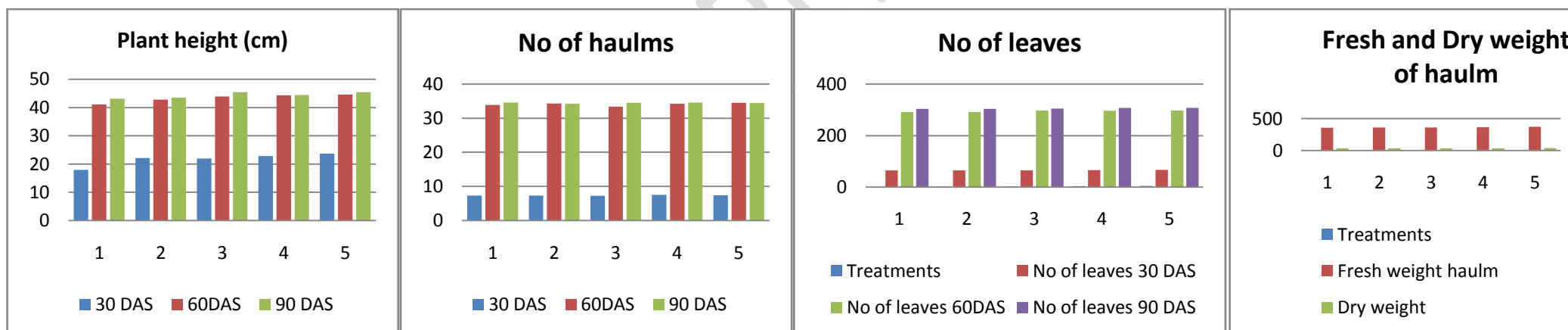


Figure 1: Effect of integrated nutrient management (INM) on growth parameters of potato

Effect of INM on yield parameters of potato

In exploring yield and its parameters under the influence of integrated nutrient management practices, data on the number of tubers per hill at harvest were meticulously recorded and detailed in the research findings. The weight categories encompassed 0-25g, 25-50g, 50-75g, and >75g. Treatment 3 consistently demonstrated superior performance, exhibiting the highest tuber counts across all weight categories. Specifically, Treatment 3 showcased pre-eminence in the 0-25g, 25-50g, and >75g weight classifications.

Similarly, the evaluation of tuber weight at harvest, documented in the research, unfolded insights into the impacts of varied treatments. Categorized into weight ranges of 0-25g, 25-50g, 50-75g, and >75g, Treatment 5 consistently manifested superior tuber weights, ranking Treatment 5 > Treatment 4 > Treatment 3 > Treatment 2 > Treatment 1. Treatment 5 asserted dominance in the >75g category, similar result reported by Barman *et al.*, 2014 and 2018, while treatment 1 registered comparatively lower tuber weights across all categories (Nongmaithem *et al.*, 2011). Crucial to potato crop assessment, tuber yield, recorded at harvest, was detailed in the research findings. The diverse treatments were significantly influenced by using critical difference at a 5% level of significance tuber yield in weight categories (0-25g, 25-50g, 50-75g, and >75g). Treatment 5 consistently exhibited the highest tuber weights across all categories, with Treatment 5 > Treatment 4 > Treatment 3 > Treatment 2 > Treatment 1 (Bongkyon *et al.*, 2004). Furthermore, treatment 5 recorded the highest tuber yield at 9.243q/ha, followed by Treatments 4, 3, 2, and 1 (Jaipaul *et al.*, 2011 and Khurana *et al.*, 2005) (Table 4 and Figure 2). These research findings highlight the considerable impact of treatment 5 on tuber development and overall potato yield, providing valuable insights for optimizing agricultural practices in scientific research.

Table 4: Effect of integrated nutrient management (INM) on yield parameters of potato

Treatment	No of tubers				Weight of tubers				Weight of tuber kg per plot			tuber yield (q/ha)
	A-Grade (0-25g)	B-Grade (25-50g)	C-Grade (50-75g)	D-Grade (>75g)	0-25g	25-50g	50-75g	>75g	25-50g	50-75g	>75g	
1	3.147	2.49	1.87	2	10.157	46.64	57.077	77.857	1.35	6.677	7.817	5.66
2	3.37	2.177	2.003	2.07	15.473	71.007	93.273	121.54	1.797	10.22	10.743	8.247
3	3.543	2.213	2.033	2.323	16.473	73.27	97.37	123.697	1.88	10.747	10.85	8.557
4	3.35	2.263	2.337	2.36	17.253	81.243	98.26	127.453	1.917	10.95	11.213	8.793
5	3.323	2.29	2.37	2.42	18.347	83.3	98.713	129.2	1.943	11.2	11.27	9.243
C.D.	0.21	0.19	0.05	0.07	0.547	0.623	0.521	0.2	0.158	0.054	0.177	0.051
SE(m)	0.092	0.1	0.015	0.111	0.165	0.188	0.157	0.06	0.048	0.016	0.053	0.015
SE(d)	0.13	0.141	0.021	0.158	0.234	0.266	0.222	0.085	0.067	0.023	0.075	0.022
C.V.	4.773	7.573	1.226	8.64	1.841	0.459	0.306	0.09	4.646	0.284	0.89	0.326

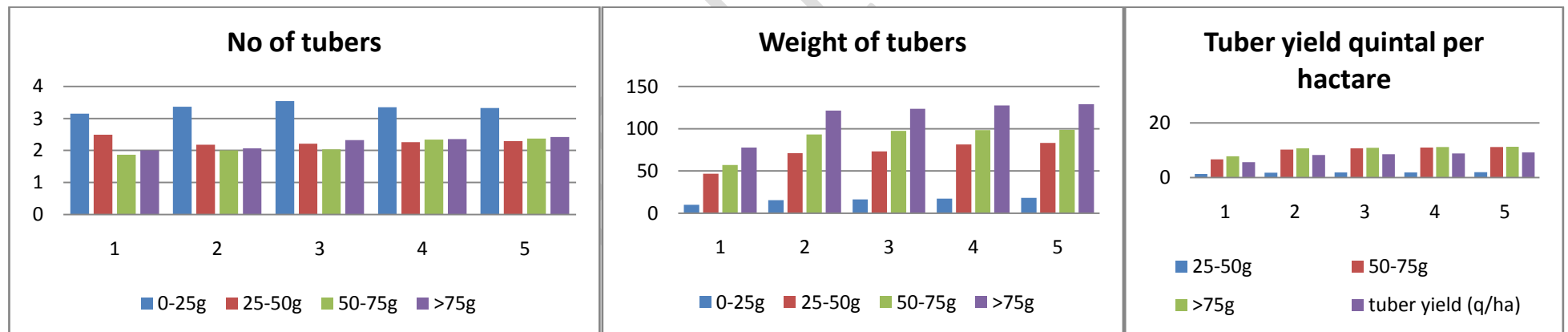


Figure 2: Effect of integrated nutrient management (INM) on yield parameters of potato

Conclusion

The comprehensive investigation into integrated nutrient management practices in potato cultivation, conducted at the Horticulture field of DCAAS College Rampur, U.K., during the Rabi season of 2022-2023, has provided valuable insights into the intricate dynamics of growth and yield for the "Kufri Chandramukhi" potato variety. The robust performance of treatment 5, characterized by higher plant weights and enhanced physiological attributes, positions it as a promising and effective nutrient management strategy for potato cultivation. In yield studies, treatment 3 consistently demonstrated high performance regarding tuber counts and weights across size categories. Treatment 5 emerged as a dominant force, displaying the highest tuber weights and yield. This underscores the intricate interplay between nutrient management practices and the physiological processes governing potato growth. Treatment 5's pronounced positive influence suggests its potential as a critical approach for optimizing potato cultivation practices in the U.K.'s horticultural context. The empirical data generated from this research contributes significantly to understanding nutrient management strategies, offering valuable insights for future endeavours aimed at refining potato cultivation practices with a focus on sustainability and productivity.

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