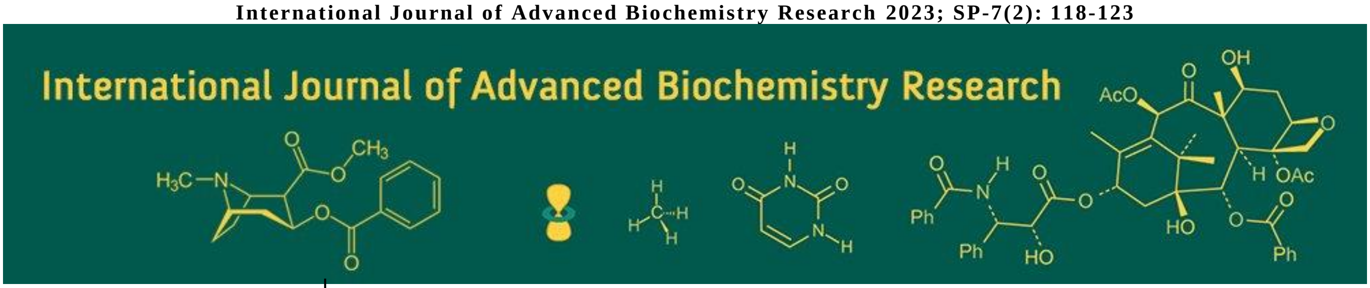

Impact of integrated nutrient management on yield and nutritional value of chickpea (*Cicer arietinum* L.)

PS Subhasmita, Laishram Zurika and Sushila Arya

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2023; SP-7(2): 118-123
www.biochemjournal.com
Received: 22-05-2023
Accepted: 24-06-2023

PS Subhasmita
Department of Agriculture,
Dev Bhoomi Uttarakhand
University, Dehradun,
Uttarakhand, India

Laishram Zurika
Department of Agriculture,
Dev Bhoomi Uttarakhand
University, Dehradun,
Uttarakhand, India

Sushila Arya
Department of Agriculture,
Dev Bhoomi Uttarakhand
University, Dehradun,
Uttarakhand, India

Corresponding Author:
PS Subhasmita
Department of Agriculture,
Dev Bhoomi Uttarakhand
University, Dehradun,
Uttarakhand, India

DOI: https://doi.org/10.33545/26174693.2023.v7.i2Sb.198

Abstract

Chickpea (*Cicer arietinum* L.) is an essential leguminous crop cultivated worldwide due to its nutritional value and economic significance. Integrated Nutrient Management (INM) is a sustainable agricultural approach that combines organic and inorganic fertilizers, crop residues, and other nutrient sources to enhance soil fertility, crop yield, and quality. This research paper aims to investigate the impact of Integrated Nutrient Management on the yield and nutritional value of chickpea, providing valuable insights for sustainable agricultural practices and food security. A field experiment was conducted over two cropping seasons, comparing the conventional nutrient management system with the integrated nutrient management approach. Results from the study demonstrated that integrated nutrient management significantly improved the yield of chickpeas compared to conventional practices. The increased yield was attributed to the judicious combination of nutrients, leading to enhanced plant growth, root development, and overall crop health. Furthermore, the nutritional analysis revealed that the chickpea grown under the integrated nutrient management system exhibited higher concentrations of essential macronutrients (protein, carbohydrates, and dietary fiber) and micronutrients (vitamins and minerals) compared to conventionally managed crops. The enhanced nutritional content signifies the potential of INM to bolster the nutritional quality of chickpeas, which can positively impact human health and dietary diversity. Additionally, the INM approach proved to be environmentally sustainable, as it reduced the dependency on chemical fertilizers and promoted the recycling of organic waste materials, contributing to soil health and fertility.

Keywords: INM, chickpea, integrated nutrient management, yield

Introduction

Chickpea (*Cicer arietinum* L.) is an essential leguminous crop known for its high nutritional value and vital contribution to global food security. However, its productivity and nutritional content are often constrained by nutrient deficiencies in the soil [1]. To address this issue, integrated nutrient management (INM) practices have gained attention as a sustainable approach to enhance crop productivity while preserving its nutritional value. Pulses have a unique capacity to maintain and restore soil fertility through biological nitrogen fixation because of their extensive root systems and leaf fall. Pulses are an essential dietary source of protein [2, 3]. India produces roughly 14.4 million tonnes of pulse grains on a surface area of about 23 million hectares. The chickpea (*Cicer arietinum* L.), which stands out for its high protein content and adaptability as a food grain, is the most common pulse crop in India's semi-arid tropics. 5.75 million tonnes of land, or 7.1 million hectares, or 30.9 percent of the total area and 39.9 percent of production, are used to grow pulses. Madhya Pradesh is the nation's leading producer of chickpeas, with a yield of 26.6 lakh tonnes/ha and a productivity of 931 kg/ha. There are 28.62 lakh acres on its surface.

Material and Method

The research experiment was conducted under MSSRF Project in Village Bhauwala, Dehradun (latitude 23° 1ºN and longitude 79° 57'E, 393 metres above sea level) in Rabi season for one year (2022-23). The soil of the experimental field was sandy loam in texture, poor in fertility in respect of available nitrogen and organic carbon and medium in respect of available phosphorus and available potassium. Soil was slightly alkaline in reaction (pH 7.70).

Experiment Design

The experiment consisted of seven treatments, replicated four folds in randomized design. The details of the layout of experiment are given in (Table 1, 2 and Figure 1).

Table 1: Experiment Layout

1	Location	Farmers Field in Bh
2	Design	RBD
3	Replications	4
4	Treatments	7
5	Crop	chickpea
6	Variety	JG-322
7	Plot size	25 x 23 m
8	Net plot size	575 m2
9	Spacing between plots	0.5 m
10	Spacing between replications	1.0 m
11	Spacing between rows	30 cm
12	Spacing between plant to plant	15 cm

Table 2: Treatment combinations

Treatment	Doses
T_1	Control
T_2	50% GRD + FYM @ 5 t/ha
T_3	100% GRD
T_4	50%o GRD + PSB 4kg/ha
T_5	50% GRD + vermicompost@ 2 t/ha
T_6	50% GRD + FYM@ 5 t/ha + PSB@ 4 kg/ha
T7	50% GRD + vermin compost @ 2 t/ha + PSB @ 4 kg/ha 18

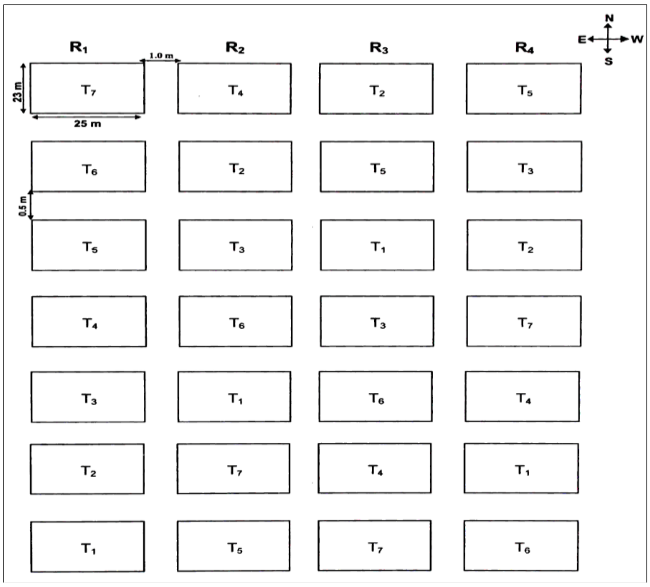

Fig 1: Experiment Layout

Plant sample preparation

In each plot, plant samples were carefully collected within a one-meter area, ensuring uniform productivity. Prior to harvesting chickpeas, the plant samples underwent a drying process in a specialized oven set at 70 °C. Afterwards, the samples were divided into separate grain and straw components.

Pre-sowing operations

In this particular experiment, a tractor was initially employed to create a well-prepared seed bed. Subsequently, a power tiller was utilized to further cultivate the soil by efficiently mixing and dispersing the dirt. The manures and fertilizers were then carefully measured and evenly spread across each designated area following the given instructions. On November 30, 2022, the crop planting phase commenced, where 80 kg per hectare of specially treated JG-322 chickpea seeds, enriched with bioculture, rhizobium, and fungicide, were sown.

Nitrogen content evaluation

The Nitrogen concentration is determined using the wet method, following the instrument analysis approach described in KELPOL's work from 1965 and AOAC's guidelines from 1965 [4, 5]. The procedure involves taking 1 gram of plant material (either straw or seeds) and mixing it with 100 ml of a digestion solution in a flask. The digestion solution contains potassium and copper sulphates in a 1:5 ratio and is added to the flask in varying amounts between 2 to 5 grams. Additionally, 10 ml of concentrated hydrochloric acid (H2SO4) is added to the flask, and the mixture is allowed to stand until it becomes clear. After cooling, the volume is adjusted to 100 ml. To initiate the distillation process, a 10 ml sample of the digestion liquid is taken and added to a separate distillation flask. Subsequently, 10 cc of sodium hydroxide (NaOH) is added. The liberated ammonia is collected in another flask containing methyl red, two drops of bromo-chloroacetic acid, and 10 ml of 2% boric acid. To ensure the complete expansion of ammonia before colour development, the distillation process is extended by an extra five minutes. Furthermore, in the acidic plant extract solution, vanadomolybdate reacts with orthophosphates, forming a yellow complex that can be used to develop a yellow colour indicative of phosphoric content. The transmittance (or absorbance) of the solution at 420 nm is measured using a spectrophotometer, following the method established by Koening and Johnson in 1942. Potassium content in the diet was tested using a Digi table flame thermometer, as outlined by Black in 1965 [4].

Sulphur content evaluation

Barium sulphate precipitate's turbidity was measured using a turbidometer, and the solution's absorbance (or transmittance) at 420 nm was calculated using turbidimetry (Bardsley and Lancaster, 1960) [5].

Organic carbon content evaluation

The rapid titration technique was used to find the organic carbon. It was created in 1934 by Walkely and Black, and Piper reported it in 1950 [6].

Phosphorus content evaluation

With the help of a technique similar to that described by Orsen *et al.* (1954), the phosphorus content of soil was extracted. With the aid of 0.5 m NaHC03 (PH 8.5), the phosphorus is eliminated from the soil. Ascorbic acid is used to calculate transmittance. Miller and Keeney established the 1982 theory behind blue colour transmittance and absorption. The spectrophotometer with a 660 nm wavelength is ready after ten minutes [7, 8].

Potassium content evaluation

By adding neutral normal ammonium acetate and measuring with a flame photometer, the amount of potassium that was made available was calculated [8].

Statistical analysis of the test results

The statistical study of grain and straw yield statistics resulted in the Panse (1970) and Sukhatme technique containing analytical data on the soil and plant [9].

Result

This study was covered under the Dehradun Town Bhauwala Facilitated Supplement. The leaders for Chickpea (MSSRF) project, which is still in process [10]. In a farmer's field, a chickpea crop was had a go at using seven remarkable treatment mixes. Comparative medications (a blend of inorganic and normal composts) were used in the assessment close by a piece that is regularly energized and an absolute control. The survey's critical goal was to evaluate the impact of consolidated supplement the chiefs (IFM) on the sound advantage and production of chickpeas [11]. The yield, protein content, and dietary advantage of grain, straw, and basic soil parts are quantifiably summarized in (Table 3-11).

Effect of various INM methods on the production of chickpea grains and straw

Table 3: Grain yield and Straw Yield (q/ha)

Treatment code	Nutrient management practice	Grain yield (q/ha)	Straw yield (q/ha)
T_1	Control	12.34	19.92
T_2	100o/o GRD	15.00	21.87
T_3	50% GRD + FYM @ 5 t ha^{-1}	16.34	26.40
T_4	50% GRD + Vermicompost @ 2 t ha^{-1}	18.42	28.66
T_5	50% GRD + PSB @ 4 kg ha^{-1}	15.43	28.82
T_6	50% GRD + FYM @ 5 t ha-1 + PSB @ 4 kg ha^{-1}	19.62	30.83
T_7	50°10 GRD + Vermicompost @ 2 t ha^{-1} + PSB @ 4 kg ha-1	21.54	32.93
	Mean	16.96	27.06
	S.Em±	1.34	2.10
	CD at 5%	3.97	6.26

Table 3 clearly demonstrates how different treatments affect the yield of chickpeas. When compared to the control or farmers' practice (FP), the introduction of FYM, vermicompost, and PSB consistently increases yields. Treatment T_1, with 50% GRD, 5 t vermicompost/ha, and 4 kg PSB/ha, resulted in the highest yield of 21.54 q/ha, significantly surpassing the control's yield of 12.34 q/ha. The test plot (25×23 m^2) also showed a significant treatment influence on both grain and straw yields. Treatment T_1 produced the most straw at 32.93 q/ha, while grain yields ranged from 12.34 to 21.54 q/ha across different treatments [12]. Overall, grain production increased by 59.0% from T_1 to T_6 treatments and by 74.5% when compared to the improvement from control to farmer practices. Similarly, straw production showed notable growth across treatments. Regarding soil pH, most treatments had minimal impact on pH levels. However, T_2 treatment did affect the soil pH, reducing it from an initial range of 7.71-7.85 to 7.61-8.03 after harvest. The overall decrease in pH was by 0.03 units.

Table 4: Effect of treatments on Soil pH

Treatment code	Nutrient management practice	Grain yield (q/ha)	Straw yield (q/ha)
T_1	Control	7.71	7.68
T_2	100o/o GRD	7.85	8.03
T_3	50% GRD + FYM @ 5 t ha^{-1}	7.82	7.83
T_4	50% GRD + Vermicompost @ 2 t ha^{-1}	7.81	7.86
T_5	50% GRD + PSB @ 4 kg ha^{-1}	7.81	7.80
T_6	50% GRD + FYM @ 5 t ha-1 + PSB @ 4 kg ha^{-1}	7.83	7.61
T_7	50°10 GRD + Vermicompost @ 2 t ha^{-1} + PSB @ 4 kg ha^{-1}	7.84	7.64
	Mean	7.81	7.78
	S.Em±	0.393	0.393
	CD at 5%	NS	NS

Effect of treatments on soil EC

Despite a slight deviation of 0.04 Dsm^{-1} from the fundamental value, the soil electrical conductivities during the hidden and post-harvest stages remained largely undefined. Examining the data presented in Table 5, it becomes apparent that the early phase variance in the equation at the post-accumulate level was found to be negligible. The initial stage equation yielded values ranging from 0.13 to 0.18, while the post-accumulate equation ranged from 0.14 to 0.19 Dsm^{-1}. The mean values for the initial stage and post-procure level were 0.15 and 0.18 Dsm-1, respectively. The electrical conductivity increased by 2% between the sample and end typical readings, indicating a minor change in the overall trend.

Table 5: Effect of treatments on Soil EC

Treatment code	Nutrient management practice	Grain yield (q/ha)	Straw yield (q/ha)
T_1	Control	0.14	0.15
T_2	100% GRD	0.16	0.17
T_3	50% GRD + FYM @ 5 t ha^{-1}	0.13	0.15
T_4	50% GRD + Vermicompost @ 2 t ha-1	0.18	0.18
T_5	50% GRD + PSB @ 4 kg ha^{-1}	0.18	0.19
T_6	50% GRD + FYM @ 5 t ha^{-1} + PSB @ 4 kg ha^{-1}	0.14	0.16
T_7	50°10 GRD + Vermicompost @ 2 t ha^{-1} + PSB @ 4 kg ha^{-1}	0.13	0.14
	Mean	0.15	0.18
	S.Em±	0.147	0.147
	CD at 5%	NS	NS

Table 6: Effect of treatments on soil organic Carbon

Treatment code	Nutrient management practice	Grain yield (q/ha)	Straw yield (q/ha)
T_1	Control	0.64	0.63
T_2	100o/o GRD	0.65	0.66
T_3	50% GRD + FYM @ 5 t ha^{-1}	0.66	0.68
T_4	50% GRD + Vermicompost @ 2 t ha-1	0.66	0.67
T_5	50% GRD + PSB @ 4 kg ha^{-1}	0.65	0.65
T_6	50% GRD + FYM @ 5 t ha-1 + PSB @ 4 kg ha^{-1}	0.68	0.70
T_7	50°10 GRD + Vermicompost @ 2 t ha^{-1} + PSB @ 4 kg ha^{-1}	0.70	0.73
	Mean	0.69	0.70
	S.Em±	0.010	0.014
	CD at 5%	0.022	0.030

Table 7: Effect of treatments on the available soil nitrogen (kg/ha)

Treatment code	Nutrient management practice	Grain yield (q/ha)	Straw yield (q/ha)
T_1	Control	215.20	210.82
T_2	100% GRD	218.30	212.37
T_3	50% GRD + FYM @ 5 t ha^{-1}	219.60	220.37
T_4	50% GRD + Vermicompost @ 2 t ha-1	222.50	230.35
T_5	50% GRD + PSB @ 4 kg ha^{-1}	219.60	227.42
T_6	50% GRD + FYM @ 5 t ha-1 + PSB @ 4 kg ha^{-1}	224.34	230.32
T_7	50°10 GRD + Vermicompost @ 2 t ha^{-1} + PSB @ 4 kg ha^{-1}	225.45	232.30
	Mean	220.72	223.43
	S.Em±	7.37	8.65
	CD at 5%	22.10	22.30

Table 8: Effect of treatments on the available soil phosphorus (kg/ha)

Treatment code	Nutrient management practice	Grain yield (q/ha)	Straw yield (q/ha)
T_1	Control	11.50	11.45
T_2	100% GRD	12.10	12.20
T_3	50% GRD + FYM @ 5 t ha^{-1}	12.30	12.85
T_4	50% GRD + Vermicompost @ 2 t ha^{-1}	11.40	13.10
T_5	50% GRD + PSB @ 4 kg ha^{-1}	12.80	12.90
T_6	50% GRD + FYM @ 5 t ha^{-1} + PSB @ 4 kg ha^{-1}	12.40	13.72
T_7	50°10 GRD + Vermicompost @ 2 t ha-1 + PSB @ 4 kg ha^{-1}	13.02	14.70
	Mean	12.22	12.96
	S.Em±	0.718	0.45
	CD at 5%	NS	NS

Table 9: Effect of treatments on the available soil potassium

Treatment code	Nutrient management practice	Grain yield (q/ha)	Straw yield (q/ha)
T_1	Control	380.00	360.00
T_2	100o/o GRD	370.00	380.0
T_3	50% GRD + FYM @ 5 t ha^{-1}	400.00	403.00
T_4	50% GRD + Vermicompost @ 2 t ha^{-1}	375.00	398.00
T_5	50% GRD + PSB @ 4 kg ha^{-1}	389.00	390.00
T_6	50% GRD + FYM @ 5 t ha-1 + PSB @ 4 kg ha^{-1}	360.00	410.00
T_7	50°10 GRD + Vermicompost @ 2 t ha^{-1} + PSB @ 4 kg ha^{-1}	420.00	426.00
	Mean	384.96	391.32
	S.Em±	20.01	24.88
	CD at 5%	NS	NS

Effects of treatment on the N, P, K, S content in grain

The nitrogen concentration of the treatments varied significantly when the grain was harvested. The lowest nitrogen content in the control was 3.13%. The highest Nitrogen concentration 3.4% (7%) was seen in the T_1 therapy. T_1 therapy includes 505 of the GRD. Vermicompost was added to 50% of the GRD and 5% of the total PSB (4 kg ha-1). T_7 showed increase of 10.86 °C, over T_1, 8.44 °C, over T_2 and 5.15 °C, over T3 when 50% of GRD +5% of FYM ha were added.

The data presented in Table 10 demonstrates that all treated plots exhibited significantly higher phosphorus accessibility in the grain stage compared to untreated plots. The difference in phosphorus content between the IPNS prescriptions was approximately 0.375 to 0.422%. Notably, the grain from the T1 treatment had the highest phosphorus concentration, with an increase of 12.53 percent compared to the control grain with 0.375 percent phosphorus [13]. Regarding the impact of treatments on grain potassium content, the results in Table 8 indicate considerable variation. The average potassium content was found to be 0.847 percent, ranging from 0.801 to 0.881 percent. The highest potassium concentration was observed in the T_1 grain, which was 9.99 percent higher than the control. Furthermore, T_3 outperformed T_2 in terms of potassium content in the grain. Examining the effects of treatments on grain sulfur content, the data in Table 8 reveals that fully treated plots experienced a significant and consistent increase in sulfur content. The sulfur content ranged from 0.280 to 0.376%, with an average value of 0.333%. Notably, the T_7 treatment had the highest sulphur content, showing a remarkable 34.29% increase compared to the control.

Table 10: Effect of treatment on the N, P, K, and S content grain

Treatment code	Nutrient management practice	N %	P %	K %	S %
T1	Control	3.130	0.375	0.801	0.280
T2	100% GRD	3.200	0.391	0.809	0.287
T3	50% GRD + FYM @ 5 t ha^{-1}	3.300	0.408	0.861	0.342
T4	50% GRD + Vermicompost @ 2 t ha^{-1}	3.290	0.410	0.863	0.342
T5	50% GRD + PSB @ 4 kg ha^{-1}	3.230	0.408	0.843	0.341
T6	50% GRD + FYM @ 5 t ha^{-1} + PSB @ 4 kg ha^{-1}	3.350	0.414	0.869	0.361
T7	50°10 GRD + Vermicompost @ 2 t ha-1 + PSB @ 4 kg ha^{-1}	3.470	0.422	0.881	0.376

	Mean	3.290	0.404	0.847	0.333
	S.Em±	0.06	0.007	0.015	0.013
	CD at 5%	0.201	0.020	0.045	0.039

Table 11: Effect of treatment on the protein content in grain

Treatment code	Nutrient management practice	% Protein Content
T1	Control	19.50
T2	100o/o GRD	20.00
T3	50% GRD + FYM @ 5 t ha^{-1}	20.62
T4	50% GRD + Vermicompost @ 2 t ha^{-1}	20.56
T5	50% GRD + PSB @ 4 kg ha^{-1}	20.12
T6	50% GRD + FYM @ 5 t ha^{-1} + PSB @ 4 kg ha^{-1}	21.12
T7	50°10 GRD + Vermicompost @ 2 t ha^{-1} + PSB @ 4 kg ha^{-1}	22.68
	Mean	20.66
	S.Em±	1.34
	CD at 5%	2.82

The crude protein factor has been multiplied in order to calculate the protein content of crops. The reserve protein in seeds may be considerably increased using a variety of techniques. While agricultural practices had the lowest protein concentrations, high-yield treatments including FYM, Vermicompost, and PSB had the highest protein concentrations. The protein level in the control was substantially higher at 21.68 percent compared to these treatments. The conclusion was a 2.56, 5.74, 5.44, 3.18, 8.31, and 16.31 percent rise in protein concentrations. 20.66% of the protein was, on average.

Conclusion

The research findings highlight the crucial role of Integrated Nutrient Management (INM) in promoting sustainable chickpea cultivation. Emphasizing the significance of INM in enhancing both crop productivity and nutritional value, this study underscores its potential to ensure food security and uplift livelihoods. The outcomes clearly demonstrate that making INM a regular practice is essential for maintaining soil health and providing the necessary balanced nutrients for sustainable crop production. By incorporating a well-designed INM system that combines appropriate amounts of fertilizers and organic manures with beneficial microbial inoculants, modern agriculture can greatly benefit. This approach will not only avert nutrient deficiencies but also contribute significantly to sustainable agriculture, bolstering economic prosperity, and improving nutrition for communities that heavily rely on chickpeas as a primary food source. Therefore, practical recommendations based on these findings are provided for farmers and policymakers to adopt INM practices effectively in chickpea cultivation [14, 15].

Credit authorship contribution statement

P S Subhasmita, Laishram Zurika: Conceptualization; Methodology; Data curation; Writing- original draft.

Sushila Arya: Review & editing; Supervision.

Declaration of Competing Interest

The authors declare no conflict of interest.

Funding

“The authors declare that no funds, grants, or other support were received during the preparation of this manuscript”.

Acknowledgement

The authors acknowledge the technical support received from the School of Agriculture, Dev Bhoomi Uttarakhand.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Reference

1. Abdul Basir, Khan Zada, Shah Z. Effect of phosphorous and farmyard manure on nitrogen nutrition. Sarhad Journal Agriculture. 2005;21(2):11-19.
2. Arya S, Kumar R, Prakash O, Kumar S, Mahawer SK, Chamoli S, *et al.* Chemical composition and biological activities of *Hedychium coccineum* Buch.-Ham. Ex Sm. essential oils from Kumaun hills of Uttarakhand. Molecules. 2022;27(15):4833.
3. Arya S, Mahawer SK, Karakoti H, Kumar R, Prakash O, Kumar S, *et al.* Study of the Variability of the Chemical Profile, and Biological Activity Approaches of *Hedychium coronarium* J. Koenig Essential Oil from Different Habitats of Uttarakhand, India. Journal of Food Quality. 2023..
4. Black CA. Method of soil Analysis Part I and II agronomy series No. 9. Amer. Soc. Agron., Inc. Madison, Wisconsin, U.S.A.
5. Chandra R. Response and economics of Rhizobium, Phosphorus and Zinc application in gram. Legume Research. 1995, 1965;18(2):103-108.
6. Bardsley CE, Lancaster JD. Determination of reserve sulfur and soluble sulfates in soils. Soil Science Society of America Journal. 1960;24(4):265-268.
7. Dixit JP, Pandey RP, Namdeo KN. Influence of phosphatic fertilizer on Bengal gram. Madras Agricultural Journal. 1983;70(7):478-479.
8. Dubey SK, Shrivastava SK. Response of Soybean of microbial inoculants. Bhartiya Krishi Anusandhan Patrika. 1991;6(4):202-206.
9. Ghosh BN, Ved Prakash, Singh RD. Yield response and nutrient use efficiency on soybean wheat system in long term manorial experiment. Proc. National workshop long-term fertility management through integrated nutrient supply system. Indian I NSTT. Soil Sci Bhopal. 1998, 27-282.
10. Gupta SC. Effect of combined inoculation on nodulation, nutrient uptake and yield of chickpea in vertisol. Journal of the Indian Society of Soil Science. 2006;54(2):251-254.
11. Hulugalle NR, Enturistle PC, Cooper JL, Scott F, Nehl DB, Allen SJ, *et al.* Sowing wheat or field peas as rotation crops after irrigation cotton in a grey vertisol. Australian J Soil Res. 1999;37(5):867-889.
12. Jain LK, Pushpendra Singh. Growth and nutrient uptake of chickpea as influenced by biofertilizer and phosphorous nutrition. Crop Res. 2003;25(3):41:413. 60.
13. Kanwar K, Pariyal SS. Influence of phosphorous management and organic manuring on uptake and yield of chickpea. Annals of Agril. 2002;28(4):642-645.

14. Kumpawat BS, Manohar SS. Response of gram to bacterial inoculation, P and micronutrients. Madras Agric. J. 1994;61(7):397-398.
15. Lindsay WL, Norvell WA. Micronutrient soil test for Zn, Cu, Fe, Mn, Agron, 84. Mac Taggart. Effect of potash levels and method of application on the yield of gram. Madras Agril. Journal. 1969;70(8):537-538.
16. Prasad R, Singh RP, Roy HK, Sinha H. Effect of fertilizer, lime and manure on some physical and chemical properties of a red loam soil under multiple cropping. J Indian Soc. Soil Sci. 1983;31:601-603.