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Response of integrated nutrient management on growth, yield, and soil nutrient status in chili (*Capsicum annuum* L.)

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Abstract
Chilli (*Capsicum annuum* L.), a widely cultivated spice crop has been yielding reduced quantities because of the inappropriate and haphazard handling of chemical fertilizers. An experiment was conducted to assess the impact of Integrated Nutrient Management (INM) on chili's growth, yield, and soil nutrient status. It was laid out in a randomized complete block design (RCBD) with 7 treatments and 3 replications. The treatments used in the study were T_1 (Control), T_2 (Recommended dose of PK, and N through FYM), T_3 (RDF + FYM), T_4 (FYM), T_5 (Doubling RDF + FYM), T_6 (RDF + FYM + 25% of N), T_7 (RDF + Poultry Manure). Among the 7 treatments performed, treatment T_5 resulted in the tallest crop height while the shortest height was observed in T_1. T_3 produced the thickest stem whereas T_1 had the thinnest stem. Maximum leaf count was observed in T_6 and the lowest in T_1. T_3 and T_6 produced the highest and lowest number of pods per plant respectively. T_3 also accounted for the highest yield per plot whereas the decline in yield potential was observed in T_1. Post-harvest nitrogen, phosphorus, and potassium content were highest in T_6, T_3, and T_7 but nitrogen content was found lowest in T_4 along with phosphorus, and potassium content in T_1. Significantly higher organic matter and pH were acquired in treatments T_6 and T_4 while the lower organic matter and pH were recorded in treatments T_4 and T_1.

Keywords: Chilli, farm yard manure, INM, poultry manure, growth, quality, yield

1. Introduction

Chili pepper (*Capsicum annuum* L.) belonging to the Solanaceae family; imperative worldwide is one of the foremost assorted spice crops. It is a species of the genus Capsicum and is indigenous to Southern North America and Northern South America. It is predominantly popular for its green pungent fruits, commonly used for culinary purposes. It is commercially important for its red color due to the chemical constituent capsaicin. Hence, chili serves diverse purposes as a spice, condiment, culinary supplement, medicine, and vegetable (Kumar *et al*., 2019) [20] Known by various names like bell pepper, hot pepper, and red pepper, it plays a pivotal role as a primary ingredient in many different cuisines globally, owing to its pungency, color, flavor, and taste. In addition, chili is a rich source of vitamins, particularly vitamins A and C enriched with K, Mg, and Fe. It is believed to possess immune-boosting properties and offer relief from conditions such as arthritis, headache, and dermatological conditions.

In Nepal, chili cultivation is widespread throughout the year, spanning all regions of the country. While chili can be grown on a wide range of soils, sandy and loam soil is considered to be the most suitable. Chili is the fourth spice crop and in 2021, the agricultural land under chili cultivation gained approximately 23,000 ha, producing nearly 184,900 MT and a per capita consumption estimated at 9.8 kg (Poudyal *et al*., 2023) [23]. The ideal temperature range for chili growth is between 20 -30 °C. However, prolonged periods of the temperature dropping below 15 °C can negatively impact growth and yield.

Integrated Nutrient Management (INM) is a holistic approach to maintaining soil fertility and ensuring optimal plant nutrient supply by combining organic and inorganic resources. It aims to sustain the desired crop productivity through the optimization of the benefits from all possible sources of plant nutrients in an integrated manner. INM involves the utilization of inorganic sources of plant nutrients as well as a source of organic plant nutrients such as FYM, poultry manure, and biofertilizers.

In the agriculture sector, there is often an imbalance in the application of chemical fertilizers leading to suboptimal yields. Moreover, the use of urea as a chemical fertilizer by the farmers is being practiced without adding any organic fertilizer which poses a challenge to the establishment of a sustainable cropping system. Studies have revealed that continuous use of sub-optimal doses of nutrients in an imbalanced proportion leads to the severe depletion of nutrient reserves in soils, causing multiple nutrient deficiencies and a decline in crop productivity. (Rathod *et al*., 2022) [1]. The application of inorganic fertilizers has only been recognized to account for over 50 percent yield increase in crops. However, it has been widely accepted that organic manure application alone could serve as a holistic approach towards achieving agriculture as it is nature-based, environment friendly, and ensures the conservation of resources for the future. Long-term studies conducted in this agroecosystem have demonstrated that the recommended application of NPK along with 10 t FYM / ha application not only sustains higher yields but also improves soil health (Kundu *et al*. 2007) [8]. Plant nutrients in the soil, whether naturally endowed or artificially maintained, play a crucial role in determining the success or failure of crop production. On the other hand, the application of in-organic fertilizers alone may affect soil health, which in turn may affect flower production (Krishnaprabu, 2020) [4]. Thus incorporation of inorganic fertilizers with organic fertilizers in soil promotes the health of soil which improves the vegetative and reproductive growth of chilli plants. A proper ratio between the organic and chemical sources is required and it should be worked out to derive the best combination of the inputs for attaining quantity and quality in chili. The integrated supply and application of macro and micro plant nutrients from chemical fertilizers and organic manures have been shown to produce higher growth, yield, and nutrient content than when they are applied alone. (Gokul *et al*., 2020) [17] Hence, the present field experiment was carried out to find out the effect of Integrated Nutrient Management on the growth yield, and nutrient status of soil for chili (*Capsicum annuum* L.) production.

2. Materials and Methods

2.1 Experiment site

The experiment was carried out on the horticulture farm of Gokuleswor Agriculture and Animal Science College, Dilasaini, Baitadi. The latitude and longitude of the research site are 29.6880°N and 80.5494°E respectively. The experiment was conducted from March 1 to July 30, 2022. It is situated at an altitude of 800-950 meters above sea level.

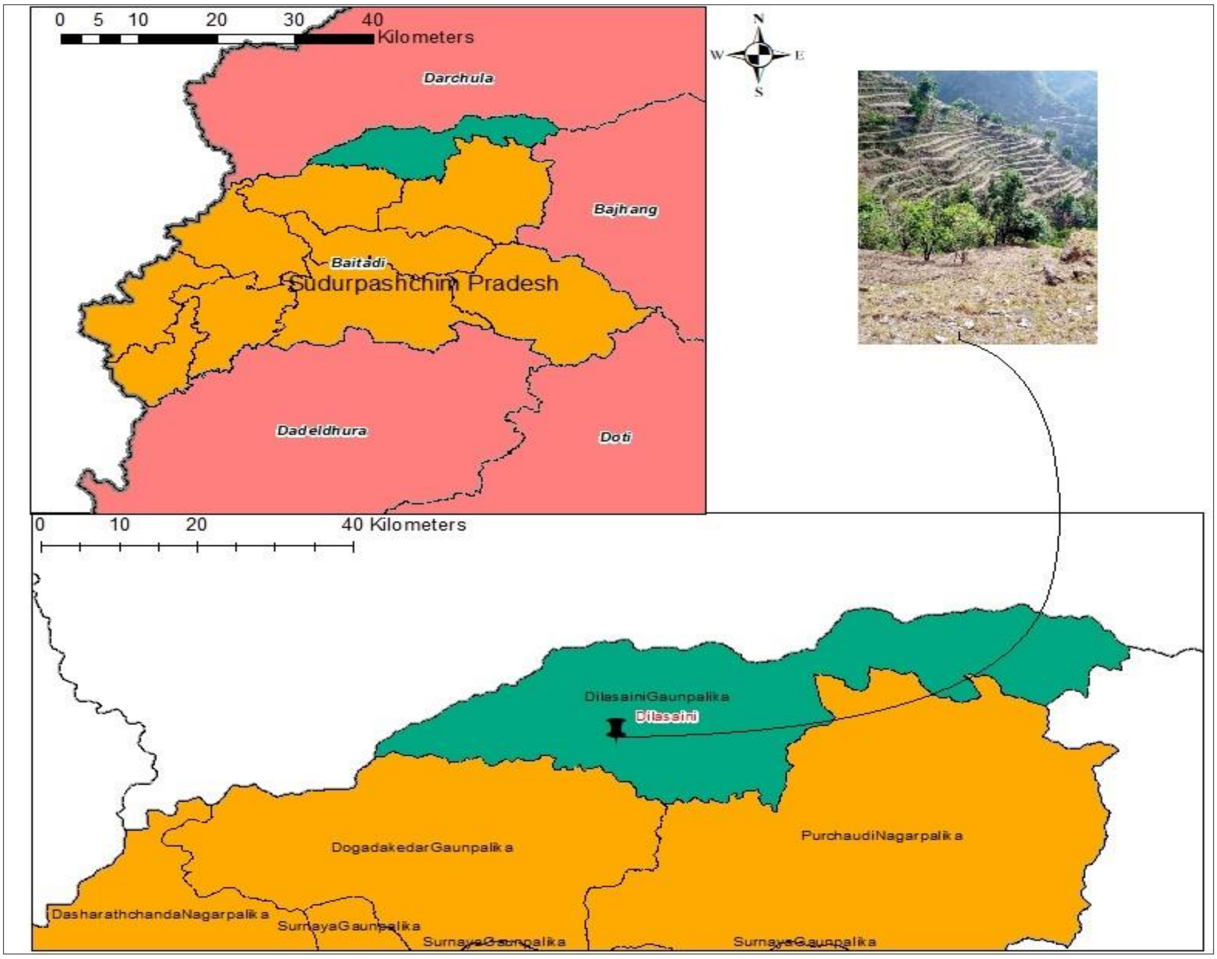

Fig 1: Map showing the study area

2.2 Climate and Weather

The experiment was conducted in the warm sub-tropical climatic zone with average summer and winter temperatures of 21.1 ℃ and 7.7 ℃ respectively. The agro-climatic feature of the research field is presented in Figure 1 (Data was made available from the agrometeorological station of Gokuleswor Agriculture and Animal Science College, Baitadi).

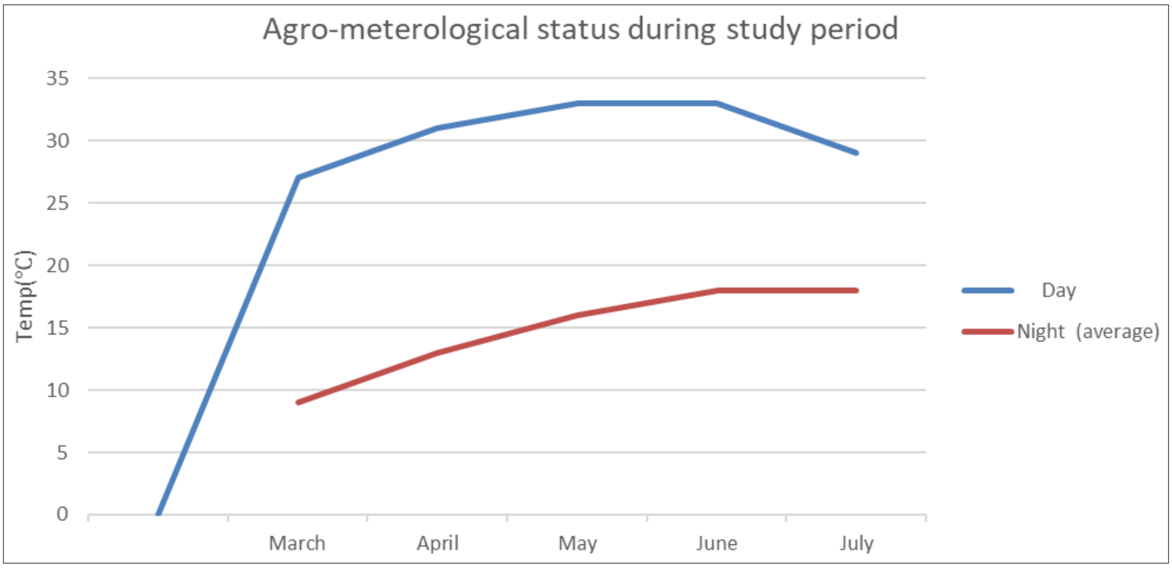

Fig 2: Agro-meteorological status during the study period.

2.3 Soil Characteristics of the experimental field

To assess the physiochemical characteristics of the soil, initial soil samples were collected from different spots within the experimental field, specifically from a depth of 0-15 cm before the application of treatment. Likewise, after the harvesting of the crop, final soil samples were collected and analyzed. A representative composite soil sample was created by processing and blending which was tested in the laboratory of Sundarpur Soil Research Center, Kanchanpur, Mahendranagar for detailed analysis. The result of the analysis is presented in Table 1.

Table 1: Initial soil physio-chemical properties before sowing chili in the field.

S.N.	Parameters	Result	Method used
1.	Organic manure	2.59%	Walkey-Black method (Matus *et al*., 2009) [11]
2.	pH	5.75	pH meter
3.	Total Nitrogen	0.13%	Kjeldahl method (Haynes, 1980; Stewart & Porter, 1963) [12, 13]
4.	Available phosphorous	21.51kgha^{-1}	Modified Olsen method (Etchevers Claudia Hidalgo Moreno Gina P Nilo & Bernaldo Florfina P Sanchez, n.d; Olsen & Dean, 1965)
5.	Available potassium	98.40 kgha^{-1}	Flame photometer (Pauline & Hald, 1946; Pratt, 1965) [9]

2.4 Experimental design and treatment details

This experiment was carried out in a Randomized Block Design (RCBD) with 7 treatments replicated 3 times. The treatments used in the study were T_1 (Control), T_2 (Recommended dose of PK, and N through FYM), T_3 (RDF + FYM), T_4 (FYM), T_5 (Doubling RDF + FYM), T_6 (RDF + FYM + 25% of N), T_7 (RDF + Poultry Manure). The total area of the experimental field was 135.24 sq. m with a standard plot size of 1.8*1.8 m^2. The distance between plot to plot and replication to replication was 0.5 m and 1 m respectively. Row to Row and Plant to Plant distance was maintained at 45*30cm.

2.5 Land Preparation and agronomic practices

Seeds of chilly were sown in a well-prepared nursery bed and raised from the ground level along with a mixing of compost. Adequate moisture was provided for the germination of the seeds and within 5-7 days the seeds began to germinate. Primary tillage in the experiment was done with the help of a tractor, while secondary tillage involved manual techniques such as spading, hoeing, and raking. Leveling was done by breaking up clods and organic manure (FYM) was applied a week before transplanting. The full dose of phosphorous and potassium and half dose of nitrogen were applied a day before transplanting. The remaining half dose of nitrogen was applied after 30 days of transplanting and at the flowering period. Every plot was raised to prevent water flooding conditions. The layout was done after leveling the field. We applied the recommended dose of fertilizer to each plot according to the aligned treatment.

Table 2: Fertilizer application details

Treatments number	Treatments used
T_1	Control
T_2	Recommended dose of PK, and N through FYM
T_3	RDF (100:100:100) + FYM (20t/ha)
T_4	FYM (20tonnes/ha)
T_5	Doubling RDF + FYM
T_6	NPK:125:100:100+ FYM(20t/ha)
T_7	RDF + Poultry Manure(5kg)

After the emergence of 2 true leaves seedling was ready for transplanting. Before transplanting, the plots were applied with the required doses of fertilizer. Transplanting was done after hardening. Planting was done at a 45*30 m^2 distance. All together 504 healthy seedlings were transplanted in the experimental layout. Gap filling was done by transplanting previously germinated seedlings. Weeding was done two times manually at 25 DAT and 45 DAT respectively. The field was immediately irrigated after transplantation to facilitate root growth into the new soil. Initially, irrigation was provided every other day but as the crop was established, the frequency was reduced to every 4-5 days. Five successive harvestings were done at 70, 80, 90, 100, and 110 DAT respectively.

2.6 Data collection
There were altogether 24 plants in each plot. Five plants were randomly selected in each plot leaving the border plants and tagged accordingly

2.6.1 Estimation of vegetative parameters
- **Plant height:** The plant height was measured in 15, 30, 45, 60, and 75 DAT using the measuring tape from the base to the tip of the plant.
- **Plant diameter:** The data for plant diameter was measured in 15, 30, 45, 60, and 75 DAT starting from just below the 1st node from the ground.
- **Number of leaves:** The number of leaves was measured in 15, 30, 45, 60, and 75 DAT.
- **Number of branches:** The number of branches was measured in 15, 30, 45, 60, and 75 DAT.

2.6.2 Reproductive parameters
- **Number of Pods:** The total number of pods was counted in 70, 80, 90, 100, and 110 DAT.
- **Yield:** The weight of the fresh fruits from each plot was recorded after harvest. The yield was measured five times at the gap of every 10 days i.e. 70, 80, 90, 100, and 110 DAT.

2.7 Statistical Analysis
The observed and collected data were entered in an MS Excel sheet in RCBD format. The entered data were analyzed with the help of GEN STAT. The mean value of all the recorded parameters was assessed and analysis of variance was done using the F-test. Duncan's Multiple Range Test (DMRT) was done. The least significant difference (LSD) test was used to determine the significance of the difference between treatment means at a 5% level of probability. The final result was interpreted with relevant literature by table and graph.

3. Results and Discussion
3.1 Effect of INM on growth parameters

Table 3: Effect of Nutrient Management on plant height at 15, 30, 45, 60, 75 DAT

Parameter Treatments	Plant height(cm)				
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
Control (T_1)	14.33	22.09	42.07	51.8^{a}	53.28^{a}
RDF of P, K and FYM (T_2)	14.83	22.34	41.8	52.67^{a}	54.45^{a}
RDF + Full dose of FYM(T_3)	12.84	20.66	43.23	58.27^{ab}	60.01^{ab}
Full dose of FYM(T_4)	15.35	24.12	44.43	55.33^{ab}	56.61^{a}
Doubling RDF+ Full dose of FYM(T_5)	12.4	19.69	43.73	70.27^{d}	72.57^{d}
RDF+ Full dose of FYM+ 25% of N(T_6)	14.9	23.1	44.97	62.2^{bc}	64.87^{bc}
RDF+ Full dose of Poultry(T_7)	15.37	23.45	44.5	65.4^{cd}	67.52^{cd}
Grand Mean	14.29	22.21	43.53	59.42	61.33
SEM	1.51	1.84	3.59	3.06	3.17
P value	0.34	0.27	0.95	<.001	<.001
LSD (0.05)	NS	NS	NS	6.66	6.91
CV (%)	12.9	10.1	10.1	6.3	6.3

Note: Mean with the same letter are non-significant at p=0.05 by DMRT, SEM=standard error of the mean, LSD=least significant difference, CV= coefficient of variation, NS=Non-significant, *: 5% level of significance, **: 1% level of significance

Plant height is a crucial yield-attributing trait that has a direct effect on biomass accumulation and production of fruits (Khandaker *et al*., 2017) [34]. Chili plant height was recorded for each treatment on 15, 30, 45, 60, and 75 DAT. It is apparent from the data presented in Table 3 that the plant height of chili at 60DAT and 75DAT was significantly influenced by different nutrient management practices and organic amendments. Numerous studies support the current findings, suggesting that integrated nutrient management plays a crucial role in enhancing the morpho-physiological characteristics of chili crops (Aslam *et al*., 2022) [30] (Baloch *et al*., 2010) [28]. The highest plant height was found in T5, which was statistically similar to T7. The lowest height was observed in the T1 (Control) treatment. The increased plant height likely results from the combination of higher doses of inorganic fertilizers with organic manure which enhances cation exchange capacity, improves water retention, and provides essential primary and secondary nutrients for optimal plant growth and height (Balbande *et al*., 2023)) [24]. A similar result of increased plant height with the increasing level of NPK combined with organic manure i.e. FYM or Poultry manure has been reported by Balliu *et al*., (2006) [16], Dubey *et al*., (2017) [2], Ahsan Altaf *et al*., (2019) [6], M, R. (2016), (Gokul *et al*., 2020) [17], (Hussain & Kerketta, 2023) [18] and Malik *et al*. (2011) [15]. Similarly, nitrogen present in poultry manure is easily available to plants because 30% of nitrogen present in poultry manure is in nitrate or ammonical form (Basnet *et al*. (2021) [3] which facilitates in rapid height growth of plants. (Mishra, 2018) [7] Recorded that NPK + Poultry manure increases the soil biomass and helps in the growth and development, enzymatic and hormonal activities of plants.

The table data demonstrates that plant growth and development benefit significantly from a combination of chemical and organic fertilizers, rather than using either type alone at recommended or higher dosages.

Table 4: Effect of nutrient management on stem diameter at 15, 30, 45, 60, 75 DAT

Plant diameter (cm)					
Treatment	**15DAT**	**30DAT**	**45DAT**	**60DAT**	**75DAT**
Control (T_1)	0.45	0.58	1.23	1.49	1.65
RDF of P, K and FYM (T_2)	0.41	0.60	1.36	1.57	1.75
RDF + Full dose of FYM(T_3)	0.43	0.58	1.45	1.55	1.80
Full dose of FYM(T_4)	0.45	0.66	1.40	1.61	1.68
Doubling RDF+ Full dose of FYM(T_5)	0.45	0.65	1.42	1.61	1.77
RDF+ Full dose of FYM+ 25% of N(T_6)	0.41	0.66	1.42	1.60	1.72
RDF+ Full dose of Poultry(T_7)	0.45	0.66	1.42	1.59	1.72
Grand Mean	0.44	0.63	1.39	1.57	1.73
SEM	0.03	0.05	0.13	0.09	0.110
P value	0.76	0.58	0.71	0.85	0.81
LSD (0.05)	NS	NS	NS	NS	NS
CV%	10.0	11.4	11.7	7.2	7.8

The different levels of NPK, FYM, and Poultry manure on stem diameter did not differ significantly due to the interaction of nutrient management practices and organic amendments. However, the maximum diameter was recorded at 75DAT in T_3 followed by T_5, and the minimum diameter was recorded in T_1 Control at 75DAT. A similar kind of result having maximum stem diameter in chili was obtained by M.R., (2016) [5]. Also, Singh *et al*., (2012) [29] and (Binte *et al*., 2021) [25] observed a progressive growth in the stem diameter of okra plants when organic fertilizers combined with inorganic fertilizers were used in acidic soil.

Table 5: Effect of nutrient management on the Number of leaves at 15, 30, 45, 60, 75 DAT

Parameter Treatment	**No. of leaves**				
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**	**75 DAT**
Control (T_1)	13.6	47.93	146.5	247.7	319
RDF of P, K and FYM (T_2)	14.6	59.73	166.3	323.2	379.7
RDF + Full dose of FYM(T_3)	13.27	49.2	149.3	322.9	392.7
Full dose of FYM(T_4)	14	68	170.3	298.9	366.1
Doubling RDF+ Full dose of FYM(T_5)	12.33	50.6	147.8	414.5	478.7
RDF+ Full dose of FYM+ 25% of N(T_6)	15.6	63.6	189.8	401	493.3
RDF+ Full dose of Poultry(T_7)	15.6	65.27	171.7	344.8	432.3
Grand Mean	14.15	57.8	163.1	336	405
SEM	3.64	12.19	19.31	70.7	70.4
P value	0.96	0.5	0.29	0.32	0.23
LSD(0.05)	NS	NS	NS	NS	NS
CV (%)	31.5	25.8	14.5	25.8	21.1

Results from Table 5 revealed that even the different levels of organic and inorganic fertilizers did not significantly influence the leaf numbers. The maximum number of leaves were observed with RDF + Full dose of FYM+ 25% of N (T_6) followed by Doubling RDF+ Full dose of FYM(T_5), and the least (319) was observed in Control (T_1). This is because administered organic and inorganic fertilizers likely contribute to more branches and leaves by reducing soil acidity and increasing nutrient availability to plants (Thirunavukkarasu & Balaji, 2015) [27]. According to Aslam *et al*. (2020) [31], increased nitrogen supplementation can improve photosynthesis, branching, and leaf growth. FYM, on the other hand, adds phosphorus and organic matter to the soil due to its high C/N ratio (Queiroz & Oliveira, 2019) [26], which promotes cell division (Aslam & Ahmad, 2020) [31].

Table 6: Effect of nutrient management on the Number of branches at 15, 30, 45, 60, 75 DAT

Parameter Treatment	**No. of branches**				
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**	**75 DAT**
Control (T_1)	0.8	5.133	12.67	19	30.47
RDF of P, K and FYM (T_2)	1.2	5.867	11.33	18.27	22.07
RDF + Full dose of FYM(T_3)	1.333	5.2	11.87	16.87	21.07
Full dose of FYM(T_4)	1.067	7.533	13.67	17.27	31.2
Doubling RDF+ Full dose of FYM(T_5)	0.733	5.133	11.53	20.27	30.13
RDF+ Full dose of FYM+ 25% of N(T_6)	1.6	6.333	13.67	18.67	28.73
RDF+ Full dose of Poultry(T_7)	0.933	6.467	12.53	19.07	26.93
Grand Mean	1.1	5.95	12.47	18.49	27.2
SEM	0.727	1.039	1.151	2.565	7.22
P value	0.89	0.26	0.30	0.86	0.69
LSD(0.05)	NS	NS	NS	NS	NS
CV (%)	81.3	21.4	11.3	17	32.5

It is evident from Table 6 that the effect of different nutrient management practices on the number of branches did not differ significantly. The maximum number of branches was recorded at 75DAT in T_4 followed by T_5 and the minimum number of branches was recorded in T_3 which was supported by the findings of Muthumanickam and Anburani (2017) [33].

Table 7: Effect of nutrient management on the number of Pods and yield at 70, 80, 90, 100, and 110 DAT DAT

Parameter Treatment	**No. of pod**	**Yield per plot (kg)**	**Yield (t/ha)**
Control (T_1)	189.3^{ab}	3.517^{a}	10.85^{a}
RDF of P, K and FYM (T_2)	193.9^{ab}	5.693^{c}	17.57^{c}
RDF + Full dose of FYM(T_3)	223.9^{b}	5.715^{c}	17.64^{c}
Full dose of FYM(T_4)	197^{ab}	5.048^{bc}	15.58^{bc}
Doubling RDF+ Full dose of FYM(T_5)	198.3^{ab}	4.25^{ab}	13.12^{ab}
RDF+ Full dose of FYM+ 25% of N(T_6)	178.6^{a}	4.964^{bc}	15.32^{bc}
RDF+ Full dose of Poultry(T_7)	192.4^{ab}	4.298^{abc}	13.27^{abc}
Grand Mean	196.2	4.78	14.76
SEM	17.71	0.599	1.848
P value	0.04	0.027	0.027
LSD(0.05)	38.59	1.304	4.02
CV(%)	11.1	15.3	15.3

Results from Table 7 indicated that the number of pods per plant of chili differs significantly influenced by different nutrient management practices and organic amendments.

A significantly higher number of pods per plant was recorded in chili which was raised with T_3 (RDF + Full dose of FYM) than T_6. Nevertheless, it was statistically similar with T_5 (Doubling RDF + Full dose of FYM), T_4 (Full dose of FYM), T_2 (Recommended dose of P, K, and FYM), T_7 (RDF + Full dose of Poultry manure), and T_1 (Control) respectively.
The chili fruit yield per plot showed significant variation, ranging from 3.517 kg (control, T_1) to the highest yield of 5.715 kg (RDF + Full dose of FYM, T_3). The second-best result was obtained with RDF of P, K, and FYM (T_2), yielding 5.693 kg of fruit. Similarly, maximum yield per ha was also observed in T_3 (17.64 ton/ha) followed by T_2 (17.57ton/ha), T_4 (15.58 ton/ha), T_6 (15.32ton/ha), T_7 (13.27ton/ha) and T_5 (13.12ton/ha). The minimum yield per ha recorded in T_1 (control) was 10.85 tons/ha as compared with other nutrient management practices. Despite T_5 and T_6 displaying higher vegetative growth than T_3, the data revealed that T_3 yielded more fruits. This could be attributed to an excess of nitrogen in T_5 and T_6, promoting prolonged vegetative growth and " luxury" consumption of N, instead of shifting to reproductive growth and efficient nitrogen use. Grzebisz *et al.* (2022) [32] also found that excessive nitrogen leads to increased non-productive plant parts, reducing maize grain yield per unit area (Potarzycki, 2010; Ciampitti *et al.*, 2013) [22, 23]. Moreover, increased yield was also related to balanced nutrition, and better uptake of nutrients by plants which helps in better fruit length, girth, and weight of fruits. The application of a recommended dose of FYM with a recommended dose of NPK increased the uptake of nutrients as compared to the other treatments. This result is closely confined to the findings of Ahasan Altaf *et al.* (2019) [6], and M.R., (2016) [5]. (Krishnaprabu, 2020) [4] found that the application of different levels of fertilizers, organic manures, and biofertilizers either alone or in combination significantly increased the growth, yield, and quality of onion as compared to the control.

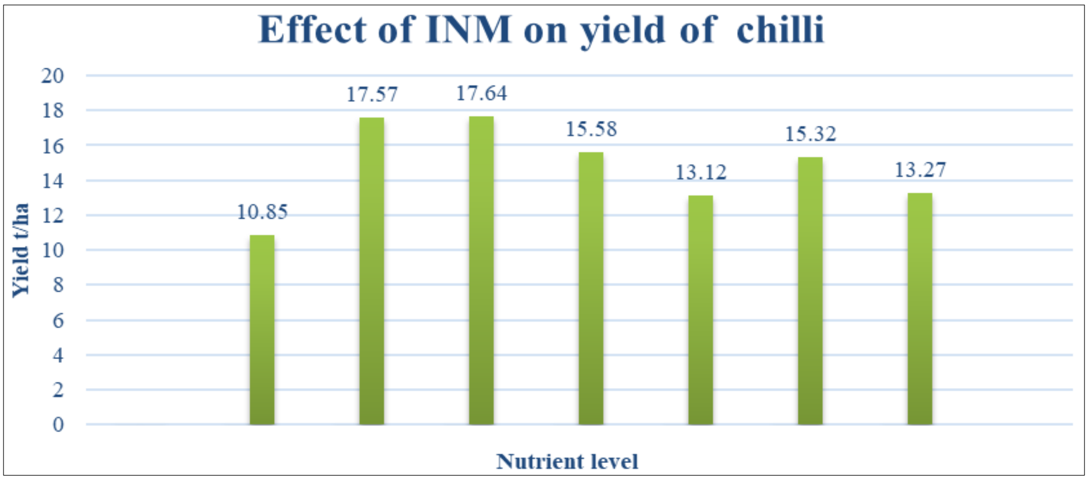

Fig 3: Effect of nutrient management on yield of Chilli

Table 8: Soil nutrients after harvest of yield

Treatment	Organic matter	PH	Total N (%)	Available P (kg/ha)	Available K (kg/ha)
Control (T_1)	2.23^b	6.17	0.11^b	19.67^c	88.71^c
RDF of P, K and FYM (T_2)	2.48^{bc}	6.23	0.12^{bc}	58.36^{ab}	141.02^b
RDF + Full dose of FYM(T_3)	2.33^{bc}	6.23	0.11^{bc}	76.92^a	132.63^{bc}
Full dose of FYM(T_4)	1.80^a	6.3	0.09^a	58.31^{ab}	131.20^{bc}
Doubling RDF+ Full dose of FYM(T_5)	2.27^{bc}	6.23	0.11^{ab}	59.94^{ab}	120.80^{bc}
RDF+ Full dose of FYM+ 25% of N(T_6)	2.67^c	6.2	0.14^c	62.29^{ab}	148^b
RDF+ Full dose of Poultry(T_7)	2.54^{bc}	6.27	0.12^{bc}	50.57^b	226.40^a
Grand mean	2.33	6.23	0.11	55.15	141.25
SEM	0.18	0.13	0.009	10.18	22.95
P value	0.01	0.96	0.01	0.88	0.002
LSD(0.05)	0.38	NS	0.019	22.18	50.01
CV (%)	9.2	2.5	9.6	22.6	19.9

Total Nitrogen

The initial nitrogen content of the field before the application of treatment was (0.13%) as shown in Table 1. Postharvest available nitrogen content in soil was found to be significant. However, the maximum nitrogen was observed in T_6 (RDF + Full dose of FYM + 25% of N) followed by T_7 (RDF+ Full dose of Poultry manure) and T_2 (Recommended dose of P, K, and FYM). The minimum nitrogen content was found in T_4 (Full dose of FYM) followed by T_1 (Control), and T_5 (Doubling RDF+ Full dose of FYM) with the same value (0.11) as mentioned in Table 8. This might be due to the addition of nitrogen through inorganic fertilizer, poultry manure, and FYM which increased the nitrogen content of plants and fruits. Similar findings were reported by (Gokul *et al.*, 2020) [17].

Organic Matter

Examination of data in the table indicates that the initial OM content in the soil before treatments was found to be 2.59%. The postharvest available OM content in soil was found to significantly maximum in T_6 (RDF+ Full dose of FYM+ 25% of N) followed by T_7 (RDF+ Full dose of Poultry manure), T_2

(Recommended dose of P, K, and FYM) and T_3 (RDF+ Full dose of FYM). The minimum OM content was found in T_1 (Control) as mentioned in Table 8.

Available Phosphorus

The initial value of available Phosphorous was found to be 21.51kg/ha as given in Table 1. Postharvest available Phosphorus content in soil was found to be significant. The maximum Phosphorus is available in the soil after harvest of the crop was observed in T_3 (RDF+ Full dose of FYM) and minimum phosphorus was found in T_1 (Control). This may be due to the application of a recommended dose of inorganic fertilizer combined with organic fertilizer. These results align with the findings of (Khanal *et al*., 2021) [19].

Available Potassium

The initial value of available potassium was found to be 98.40 kg/ha as shown in Table 1. A critical look at the data in Table 8 shows that available potassium in the soil after the harvest of the crop differs significantly. Data presented in Table 8 revealed that maximum potassium depletion was shown in T_1 (Control) and minimum depletion was shown in T_7 (RDF+ Poultry manure). This may be due to the application of a recommended dose of inorganic fertilizer combined with organic fertilizer. These results conform with the findings of (Gokul *et al*., 2020) [17]. The increased potassium content in soil might be due to better mineralization of nutrients from poultry manure.

pH

The initial value of PH was found to be 5.75 as given in Table 1. A critical look at the data shows that the available pH in the soil after the harvest of the crop did not differ significantly.

Table 9: Economics of chili production

Particulars	Amount (NRs/ha)
Rental value of land	15,000
Field preparation	20,000
Seed cost	8,000
Irrigation cost	20,000
Weeding	15,000
Harvesting	25,000
Total	1,03,000

Note: NRs: Nepalese Rupees, ha: hectare.

Table 10: Estimation of cost of different components.

Treatments	Common cost(NRs/ha)	Respective manures	Cost of Fertilizers (NRs/ha)			Total cost (NRs/ha)
			Urea	Diammonium phosphate	Muriate of potash	
T_1	1,03,000	-	-	-	-	1,03,000
T_2	1,03,000	60,000	-	10869.565	6,666.68	1,80,536.245
T_3	1,03,000	60,000	5293.004	10869.565	6,666.68	1,85,829.249
T_4	1,03,000	60,000	-	-	-	1,63,000
T_5	1,03,000	60,000	10586.008	21739.13	13333.36	2,08,658.498
T_6	1,03,000	25%N=13323.251	5293.004	10869.565	6,666.68	187152.5
T_7	1,03,000	3,08,641.974	5293.004	10869.565	6,666.68	331471.223

Note: NRs: Nepalese Rupees, ha: hectare.

Table 11: Benefit-Cost (BC) ratio of cultivation of Chilli.

Treatments	Benefit (NRs/ha)	Total cost (NRs/ha)	BC ratio
T_1	548000	103000	5.320
T_2	873663.755	180536.245	4.84
T_3	872570.751	185829.249	4.69
T_4	771800	163000	4.73
T_5	578541.502	208658.498	2.77
T_6	732047.5	187152.5	3.91
T_7	464728.77	331471.223	1.40

Note: Selling Price estimated at Nrs. 60 per kg Chili, BC: Benefit-cost, NRs: Nepalese Rupees, ha: hectare.

The benefit-cost ratio is a crucial indicator in evaluating the economic efficiency of different treatments. Table 11 shows that the BC ratio was found to be highest in T_1 (5.320) followed by T_2, T_4, and T_3 while T_5, T_6, and T_7 had lower BC ratios. T_3 (RDF of PK and FYM) exhibits a favorable BC ratio of 4.69 indicating that it is economically viable and efficient.

4. Conclusion

From the above findings, it can be concluded that balanced application of a recommended dose of NPK, FYM, and Poultry manure significantly improves soil fertility status, increases crop productivity, and promotes soil health in a sustainable manner. The soil devoid of any nutrients results in poor growth and yield while the addition of nutrients from both organic and inorganic sources results in higher growth and yield. Thus, proper INM modeling can effectively enhance soil quality and chili yield. Integrated use of organic manures along with synthetic fertilizers is cost-effective and enhances soil fertility status rather than an increased rate of synthetic fertilizer. These findings serve as a foundation for further research endeavors.

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