RESEARCH ARTICLE

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COMPARATIVE ANALYSIS OF THE EFFECTIVENESS OF ORGANIC AND INORGANIC NITROGEN SOURCES ON POTATO YIELD AND SOIL FERTILITY

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ABSTRACT

Potato is a vital food source for the high hills of Nepal. The crop requires the right amount of nutrient at the appropriate time for optimal growth and production. However, the low availability, high cost, and inappropriate timing of applying nitrogenous fertilizers like urea have made it challenging for farmers to use the correct amount in their fields. Therefore, affordable and renewable sources of plant nutrients should be used to supplement chemical fertilizers. In addition to this, using organic sources can improve soil properties. To determine the effects of nitrogen supplied through different sources, an experiment was conducted in a randomized block design. There were eight treatments, each with a different combination of nitrogen supplied through urea and various organic sources as N1(100% rec N via Urea), N2 (50 % rec N via FYM + 50 % rec N via Urea), N3 (50 % rec N via PM + 50 % rec N via Urea), N4(50 % rec N via GM + 50 % rec N via Urea) , N5 (75 % rec N via FYM + 25 % rec N via Urea), N6 (75 % rec N via PM + 25 % rec N via Urea), N7 (75 % rec N via GM + 25 % rec N via Urea), N8 (Farmer practices (FYM 10 t ha-1)). The yield of potato tubers was significantly higher when recommended nitrogen was applied 50% through organic manure like poultry, FYM, and goat, and 50% through urea than other treatments, including farmer practice of using 10 t ha-1 FYM. However, the yield was statistically at par with nitrogen via sole urea. Additionally, the application of organic manures led to an increase in soil properties such as organic manure content, nitrogen, phosphorous, and potassium content. In conclusion, application of recommended nitrogen as 50% via organic manures like poultry, FYM, and goat, and 50% N via urea can enhance potato yield while also positively affecting soil properties.

1. INTRODUCTION

Potato is a crucial food source in the high hills of Nepal and are highly versatile in the kitchen as they complement various vegetables. It is the fifth most important staple food after rice, wheat, maize, and millet. The Central Bureau of Statistics (CBS), 2019 had reported that the average yearly per capita potato consumption in Nepal is approximately 29.9 kilograms and contribute 2.17% to the national GDP and 6.57% to the AGDP. However, the national productivity of potato is very low as compared to other neighboring countries (Upadhyay and Timilsina, 2020). One possible reason for this is the inadequate and haphazard application of chemical fertilizers (Subedi *et al*., 2019).

Production of an average yield per hectare of potato tuber requires a large amount of nutrients. The yield of a fully grown potato crop, which is typically between 25-30 t ha^{-1}, results in the removal of approximately 110 kg of nitrogen, 50 kg of P_2O_5, and 225 kg of K_2O per hectare (Choudhary, 1990). Among this primary nutrient nitrogen is most important and is crucial for increasing plant height, leaf area index, shoot dry matter, and tuber yield (Najm, *et al*., 2010). However, many Nepalese farmers cannot afford to purchase huge quantity of nitrogenous fertilizer like urea, which is often in short supply and expensive. Furthermore, the unbalanced and excessive use of nitrogenous fertilizer

has degraded the soil, increasing soil acidification, impairing soil physical condition, reducing soil organic matter, creating micronutrient deficiencies, decreasing soil microbial population, and causing environmental pollution.

Fortunately, organic manures such as farmyard manure (FYM), poultry manure, and goat manure are affordable and renewable options for supplementing chemical fertilizers. Farmers in Nepal often integrate their crop husbandry with the rearing of cattle, poultry, goats, and other domestic animals, and the waste from these animals can be used as manure in potato fields. Organic manures supply essential nutrients to plants, including nitrogen, and improve soil quality by enhancing soil aggregation, increasing water and nutrient retention, regulating soil pH, and reducing disease incidence. Combining inorganic fertilizers and organic manure has been shown to have a significant effect on the yield of potatoes (Iqbal, *et al*., 2019).

2. MATERIALS AND METHODS

An experiment was carried out in Pyuthan, a mid-hill region of Nepal, to investigate the effects of nitrogen supplied through inorganic and various organic sources on the growth and yield of Khumal rato-2 variety of potatoes. The soil at the site was sandy loam in texture, slightly basic in reaction (pH 7.7) with low organic matter content (1.63 %), and had total nitrogen, available phosphorus, and exchangeable potassium levels of 0.08%, 23.8 kgha^{-1}, and 370.8 kgha^{-1}, respectively. The experiment was designed as a Randomized Complete Block Design with three replications and eight treatments (table 1). The experiment consisted of 24 plots, each measuring 3.5 ×1 m^2. The recommended dose of fertilizer (NPK) and FYM was 100:100:60 kgha^{-1} and 20 t ha^{-1}, respectively. The required amount of organic manure as treatment were calculated based on nitrogen content of respective organic manure as in table 2. The recommended dose of FYM and organic manures as treatments were applied ten days before planting, and the full dose of phosphorous, potassium, and the initial dose of nitrogen were applied as a basal dose at the time of planting. Potato tubers were planted at a spacing of 75 cm × 25 cm. All the intercultural operations such as earthing up, weeding, and irrigation were performed during the growth stages of the potato. The biometric and morphological characteristics of ten tagged plants were recorded at different specified periods, and after the crop harvest, the data on yield and yield attributes were recorded. The data were first tabulated in Microsoft Excel and analyzed using R-studio. The means were separated using Duncan's Multiple Range Test (DMRT) at the 1% and 5% levels of significance (Gomez and Gomez, 1984).

Table 1. Treatment details

S.N.	Treatment	Detail
1	N_1	100% rec N via Urea
2	N_2	50 % rec N via FYM + 50 % N via Urea
3	N_3	50 % rec N via PM+ 50 % via Urea
4	N_4	50 % rec N via GM + 50 % via Urea
5	N_5	75 % rec N via FYM + 25 % via Urea
6	N_6	75 % rec N via PM + 25 % via Urea
7	N_7	75 % rec N via GM + 25 % via Urea
8	N_8	Farmer practices (10 t FYM/ha)

Table 2. Nutrient status of various organic manures

S.N.	Organic Manure	N (%)	P_2O_5 (%)	K_2O (%)
1.	Farm Yard Manure (FYM)	0.79	0.37	0.78
2.	Poultry Manure (PM)	3.3	2.1	1.3
3.	Goat Manure (GM)	2.15	0.93	1.8

3. RESULTS AND DISCUSSION

3.1 Effect on height of plant

Height of plant was significantly ($p< 0.05$) effected by source of nitrogen at 60 DAS, 75 DAS, and 90 DAS but was non-significant at 45 DAS (table 3). At 60 DAS significantly higher plants were observed when 100% recommended N via urea, 50 % recommended N via FYM + 50 % recommended N via Urea, 50 % recommended N via GM + 50 % recommended N via Urea than Farmer practices (10 t FYMha^{-1}) and 50 % recommended N via PM + 50 % recommended N via Urea, 75 % recommended N via FYM + 25 % recommended N via Urea, 75 % recommended N via PM + 25 % recommended N via Urea and was statistically at par with highest one. Similarly, at 75 and 90 DAS significantly highest plant height was observed at 100 % recommended N via urea than Farmer practice its sole application of 10 t ha^{-1}FYM.

Plant height was recorded significantly higher in sole application of urea for nitrogen or in combination with different organic manure i.e., Poultry Manure, FYM, and Goat Manure than Farmer's practice. Similar

result was observed by (Islam, *et al*., 2021). This might be due to quick N through Urea in case of sole urea and in contrast lower yield in case of farmer practice might be slow mineralization of nutrient from organic source may not synchronize the nutrient demand of crop (Sharma, 2017). Similarly, above ground biomass was higher in above mentioned treatments that might have resulted in higher accumulation of photosynthates that might contributed in increased size and number of tubers (Congera, *et al*., 2022).

Table 3. Effects of Nitrogen through organic and inorganic source on height of potato plant at Pyuthan

	Plant height (cm)			
Treatments	**45DAS**	**60DAS**	**75DAS**	**90DAS**
100% rec N via Urea	14.60	31.27^{a}	39.20^{a}	40.27^{a}
50 % rec N via FYM + 50 % via Urea	12.47	28.47^{a}	31.83^{ab}	31.83^{a}
50 % rec N via PM + 50 % via Urea	12.92	24.23^{ab}	36.90^{ab}	39.80^{a}
50 % rec N via GM + 50 % via Urea	11.73	26.80^{a}	33.10^{ab}	35.37^{a}
75 % rec N via FYM + 25 % via Urea	12.50	21.33^{ab}	26.80^{b}	30.20^{a}
75 % rec N via PM + 25 % via Urea	13.73	23.57^{ab}	29.17^{ab}	30.13^{a}
75 % rec N via GM + 25 % via Urea	10.73	23.50^{ab}	28.67^{b}	29.67^{a}
Farmer practices (10 t FYMha^{-1})	8.87	14.40^{b}	15.67^{c}	16.93^{b}
LSD	NS	9.158*	9.872**	10.546**
sem (±)	0.630	1.793	2.547	2.603
C.V.	20.43	21.61	18.70	18.95
Grand mean	12.19	24.20	30.17	31.78

Treatment means in columns followed by common letters are not significantly different from each other based on DMR at 5% level of significance

3.2 Effect on number of leaves

Number of leaves in potato plants were not significantly affected ($p<0.05$) by nitrogen from different sources at all stages of growth after sowing, including 45, 60, 75, and 90 days (table 4). The average number of leaves at 45 days after sowing was 29 and continued to increase until 75 days after sowing, where it reached 36, but then decreased to 35 at 90 days after sowing.

Table 4. Effects of Nitrogen through organic and inorganic source on leaf number of potato at Pyuthan

	Number of leaves			
Treatments	**45DAS**	**60DAS**	**75DAS**	**90DAS**
100% rec N via Urea	29	33	41	40
50 % rec N via FYM + 50 % via Urea	28	31	36	35
50 % rec N via PM + 50 % via Urea	34	36	40	38
50 % rec N via GM + 50 % via Urea	25	33	38	37
75 % rec N via FYM + 25 % via Urea	35	29	36	34
75 % rec N via PM + 25 % via Urea	28	31	36	35
75 % rec N via GM + 25 % via Urea	33	30	35	32
Farmer practices (10 t FYMha^{-1})	16	23	25	25
LSD	NS	NS	NS	NS
sem (±)	2.13	1.29	1.70	1.63
C.V.	24.00	17.34	15.76	17.49
Grand mean	29	31	36	35

Treatment means in columns followed by common letters are not significantly different from each other based on DMR at 5% level of significance

3.3 Effect on yield and yield attributes

The use of different nitrogen sources, both organic and inorganic, had a significant effect ($p<0.05$) on the average weight of tubers (figure 1). The highest tuber weight of 15.23 gm was recorded with 100% recommended N applied using Urea, surpassing other treatments. For instance, tubers weighed 11.79 gm with 50% recommended N via FYM + 50% recommended N via Urea, 12.01 gm with 75% recommended N via PM + 25% recommended N via Urea, 10.45 gm with 75% recommended N via FYM + 25% recommended N via Urea, 9.59 gm with 75% recommended N via GM + 25% recommended N via Urea, and 2.44 gm with sole FYM application. However, tubers from 50% recommended N via PM + 50% recommended N via Urea weighed 13.52 gm, and 50% recommended N via GM + 50% recommended N via Urea weighed 13.17 gm, which were statistically similar to the 15.23 gm weight obtained with 100% recommended N through Urea.

The number of tubers per plant was also significantly ($p<0.05$) influenced by the application of nitrogen through organic and inorganic sources (figure 2). The highest number of tubers per plant was obtained from 100% recommended N via Urea (13 tubers/plant) compared to other treatments such as 75% recommended N via FYM + 25% N via Urea (9 tubers/plant)), 75% recommended N via GM + 25% recommended N via Urea (9 tubers/plant)), and solely through FYM (5 tubers/plant)). Additionally, the remaining treatments, including 50% recommended N via PM+ 50% N via Urea (12 tubers/plant)), 50% N via GM+ 50% recommended N via Urea (11 tubers/plant)), and 50% recommended N via FYM + 50% recommended N via Urea (11 tubers/plant)), as well as 75% recommended N via PM + 25% recommended N via Urea (10 tubers/plant)), were statistically similar to 100% N via Urea (13 tubers/plant)).

The potato tuber yield was significantly ($p<0.05$) affected by the application of nitrogen from different sources, both organic and inorganic, as shown in figure 3. The highest yield was obtained when 100% recommended nitrogen was applied via Urea (9.53 t ha^{-1}), and 50% recommended N Via PM + 50% N via Urea (9.50 t ha^{-1}), as compared to 75% recommended N Via PM + 25% recommended N Via Urea (6.77 t ha^{-1}), 75% recommended N Via FYM + 25% recommended N Via Urea (6.62 t ha^{-1}), 75% recommended N Via GM + 25% recommended N Via Urea (4.49 t ha^{-1}), and solely through FYM (1.53 t ha^{-1}). Similarly, the yield obtained from the plots treated with 50% recommended N Via GM + 50% recommended N Via Urea (8.27 t ha^{-1}) and 50% recommended N Via FYM + 50% N Via Urea (8.20 t ha^{-1}) was statistically equivalent to t hat of 50% N Via PM+ 50% N Via Urea (9.50 t ha^{-1}). Additionally, the lowest tuber weight (1.53 t ha^{-1}) was observed from the farmer practice where 10 t ha^{-1} FYM was applied.

The application of nitrogen, whether through organic or inorganic sources, had a significant ($p<0.05$) impact on the yield of biomass, as demonstrated in figure 4. The highest weight of potato biomass was obtained from 100% recommended Nitrogen applied via Urea (6.62 t ha^{-1}), which outperformed other treatments such as 75% recommended N Via FYM+ 25% recommended N via Urea (4.24t ha^{-1}) and solely through FYM (2.76t ha^{-1}). Moreover, the remaining treatments, including 50% recommended Nitrogen through Poultry Manure + 50% recommended Nitrogen through Urea (5.69 t ha^{-1}), 50% recommended Nitrogen through Goat Manure + 50% recommended Nitrogen through Urea (5.43 t ha^{-1}),75% recommended Nitrogen through Poultry Manure + 25% recommended Nitrogen through Urea (4.86 t ha^{-1}), and 50% recommended Nitrogen through FYM + 50% recommended Nitrogen through Urea (4.80 t ha^{-1}), as well as 75% recommended nitrogen through GM +25% recommended nitrogen through Urea (4.76 t ha^{-1}), had similar statistical results as 100% recommended nitrogen applied through Urea (6.62 t ha^{-1}).

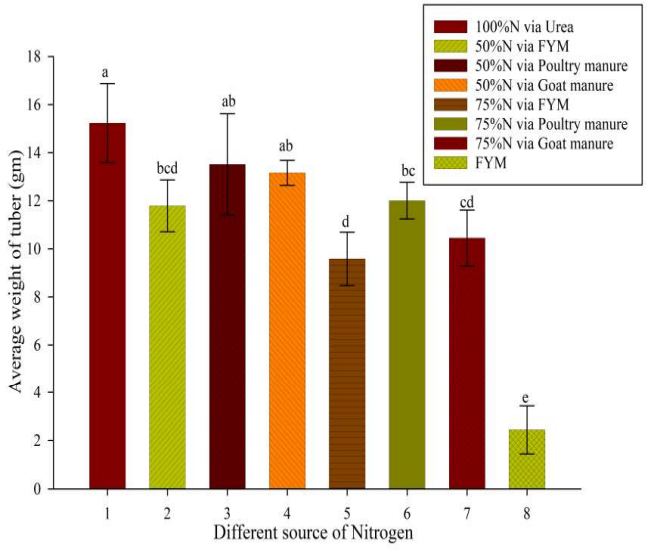

Figure 1. Average weight of a tuber as influenced by nitrogen from different sources

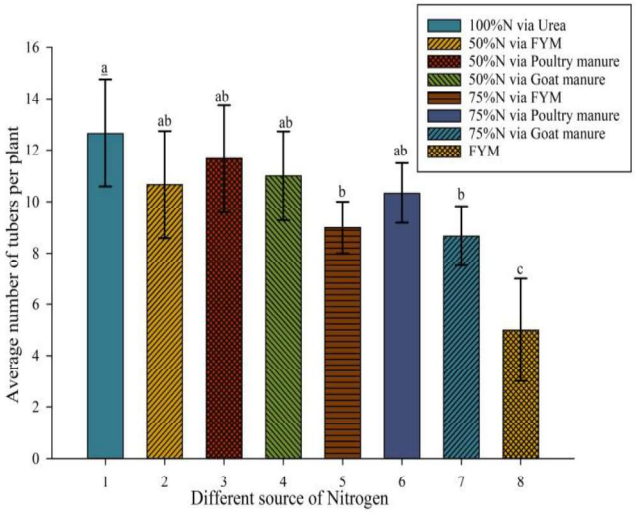

Figure 2. Number of a tubers as influenced by nitrogen from different sources

Means on bar graph not connected by same letters are significantly different by DMRT ($p< 0.05$)

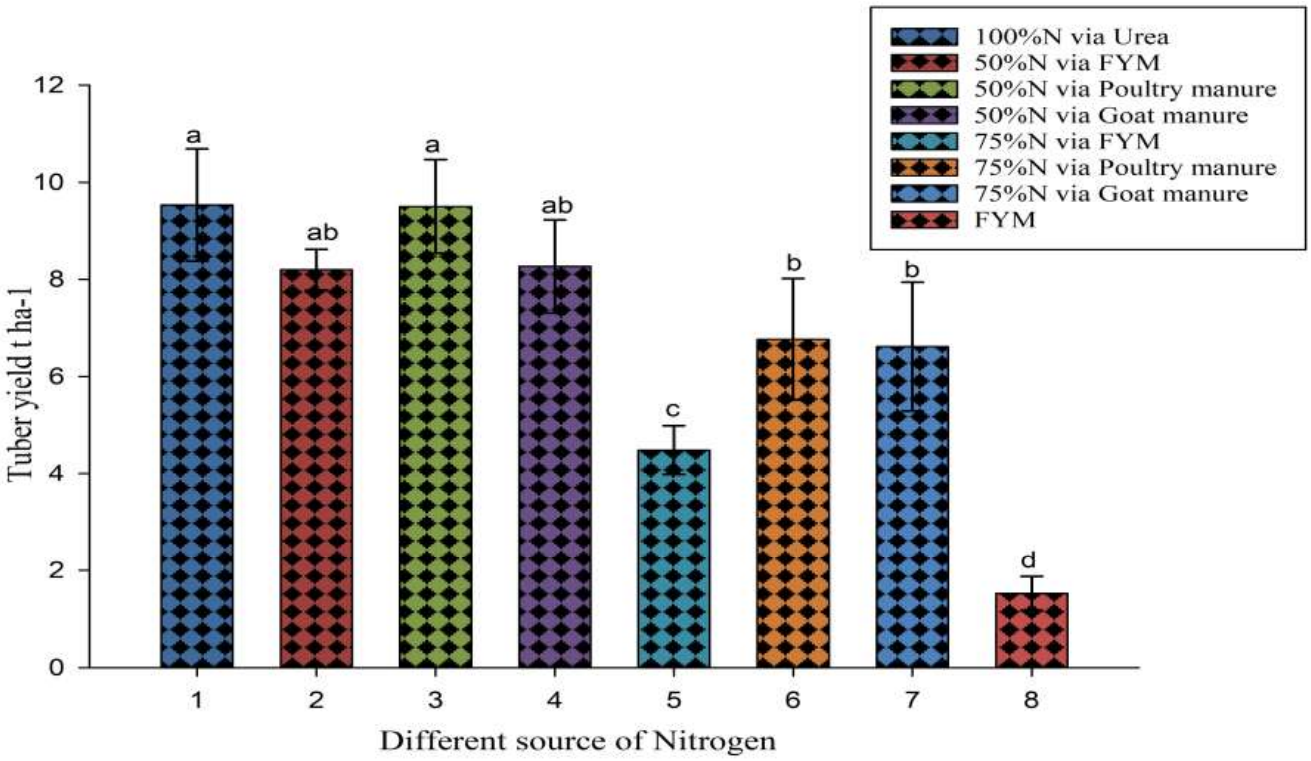

Figure 3: Effect of different source nitrogen on tuber yield of potato tuber
Means on bar graph not connected by same letters are significantly different by DMRT ($p< 0.05$)

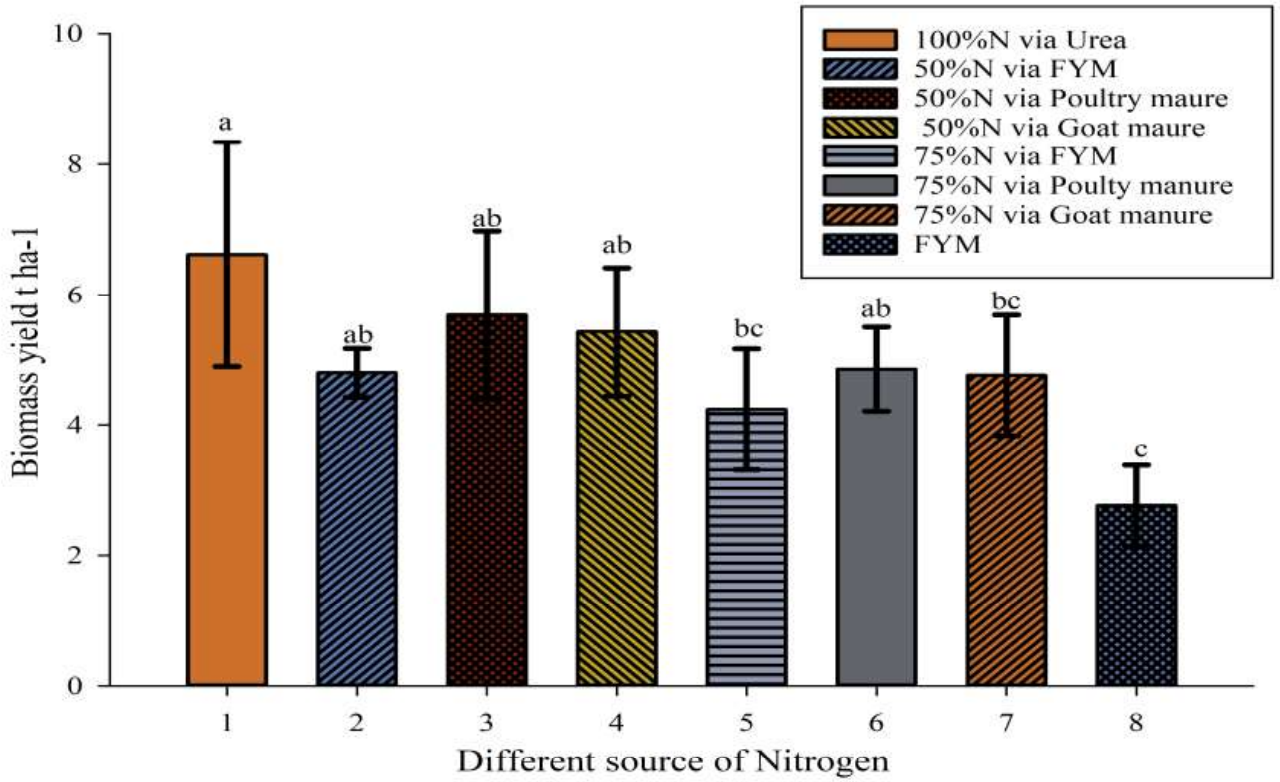

Figure 4: Effect of different source nitrogen on tuber yield of potato biomass yield (t/ha)
Means on bar graph not connected by same letters are significantly different by DMRT ($p< 0.05$)

The recommended dose of nitrogen was applied solely through urea or with 50% urea and 50% recommended nitrogen from different organic manures like FYM, Poultry, and Goat, had significantly higher numbers of potato tubers and higher average potato tuber yield than those with only 25% recommended nitrogen from urea and 75% recommended nitrogen from organic manure like FYM, Goat, and the farmer's practice. Pandey *et al*. (2022) found that the potato yield was higher when N is applied in combination of both organic and inorganic source in case of poultry and goat manure. Similarly, in case of poultry manure Mohammed and Dawa, (2018) found higher yield of potato tubers when nutrients are applied via both organic and inorganic source. The reasons for this may be due to the balanced supply of nutrients from both sources, which can promote better plant growth, leading to more significant root development, and ultimately more tubers per plant. In addition to that there is good synergistic effect of the two fertilizers in 50-50 proportion as organic manures enhance the soil physical, chemical, and biological properties, leading to better nutrient availability and uptake by the plant. In contrast, synthetic fertilizers provide a quick supply of essential nutrients, which can boost plant growth and development. The yield of potato tuber was recorded significantly highest in sole application of inorganic nitrogen through urea or supplying 50% recommended N via Urea + 50% recommended N via organic manure like FYM, Poultry, Goat than supplying 50% recommended N via Urea + 75% recommended N via organic manures and farmer practices this might be due to contribution of larger average tuber weight and a greater number of tubers per plant.

3.4 Effect on soil fertility

Table 5 indicates that the use of nitrogen from both organic and inorganic sources had a positive impact on various soil properties, such as organic matter content, nitrogen, phosphorus, potassium, and pH. The application of farmyard manure (FYM) and urea in a ratio of 75:25 resulted in the highest organic matter content. This is because organic manures, such as FYM, are rich in organic matter. It is possible that a higher quantity of FYM was applied to meet the nitrogen dose required for the plant. Similarly, applying 50% of the recommended nitrogen through poultry manure (PM) and 50% recommended N through urea resulted in higher availability of major plant nutrients, such as nitrogen, phosphorus, and potassium. This is because poultry manure contains a higher amount of nutrients and mineralizes more quickly than other manures, which results in more nutrients being released in the soil. Similar findings were reported by Rayne and Lawrence (2020).

Table 5. Effects of nitrogen from organic and inorganic sources on soil fertility when applied in a potato at Pyuthan

Treatment	OM	N	P_2O_5	K_2O	pH
100% rec N via Urea	1.63	0.13	51.9	394.8	7.7
50 % rec N via FYM + 50 % via Urea	2.96	0.11	62.1	350	7.8
50 % rec N via PM + 50 % via Urea	2.12	0.16	92.4	470.8	7.7
50 % rec N via GM + 50 % via Urea	2.61	0.11	41.9	373.2	7.8
75 % rec N via FYM + 25 % via Urea	3.27	0.07	45.2	350	7.8
75 % rec N via PM + 25 % via Urea	2.12	0.11	71.9	373.2	7.7
75 % rec N via GM + 25 % via Urea	2.13	0.08	63.6	347.2	7.8
Farmer practices (10 FYM t ha^{-1})	2.94	0.15	73.3	206.8	7.8
Before Test	1.31	0.08	23.8	370.8	7.7

CONCLUSION

In this experiment, plant growth, tuber yield was significantly higher when nitrogen was applied in 50 % recommended N via urea and 50 % recommended N via organic manures like Poultry Manure, FYM, and Goat manure. Thus, it could be concluded that application of nitrogen in inorganic (urea) and organic source in 50-50 ratio for higher potato tuber yield at the same time enhance the soil fertility status of particular soil.

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