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RESEARCH PAPER

Effect of Organic Manures and Fertilizers on Growth and Yield of Knol Khol *(Brassica oleracea var. gongylodes L.)* in the Western Terai Region of Nepal

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ABSTRACT

A field experiment was carried out at the Institute of Agriculture and Animal Science (IAAS), Rupandehi, Nepal to investigate the effect of different organic manures, fertilizers, and their combination on the growth and yield of the White Viana variety of *knol-khol (Brassica oleracea var. gongylodes L.)*. Randomized complete block design (RCBD) was used in experimenting, with three replications. The eight different treatments were T_1 (FYM 20 ton ha^{-1}), T_2 (FYM 15 ton ha^{-1}), T_3 (PM 20 ton ha^{-1}), T_4 (Half of Recommended dose of fertilizers 60:40:45 kg NPK ha^{-1}), T_5 (FYM 15 ton ha^{-1} + Half of Recommended dose of fertilizers 60:40:45 kg NPK ha^{-1}), T_6 (FYM 10 ton ha^{-1} + Half of Recommended dose of fertilizers 60:40:45 kg NPK ha^{-1}), T_7 (PM 15 ton ha^{-1} + Half of Recommended dose of fertilizers 60:40:45 kg NPK ha^{-1}), T_8 (control). The maximum plant height (27.21 cm), leaf length (23.74 cm), leaf width (10.53 cm), crown spread (50.88 cm), knob diameter (20.02 cm), biological yield (538.56 g), and biological yield per hectare (21.54 t ha^{-1}) observed in T_7. The maximum number of leaves (17.4), and harvest index (83.93 %) were recorded in T_3 while the highest marketable yield (428 g) and marketable yield per hectare (17.12 t ha^{-1}) was observed in T_5. In summary, the application of poultry manure @ 15 ton ha^{-1} + Half of the Recommended dose of fertilizers 60:40:45kg NPK ha^{-1} was observed superior over other treatments in Paklihawa, Rupandehi condition of Nepal.

HIGHLIGHTS

- Combined application of organic and inorganic fertilizers enhanced the growth and yield of *knol-khol*.

Keywords: FYM, knob, organic and inorganic fertilizers, Poultry manure, and yield

Knol-Khol (*Brassica oleracea var. gangylodes*) is a cole crop belonging to the Brassicaceae family (Chauhan *et al.* 2012). Bos and Som (2001) reported the cultivation of *knol-khol* was done by the Romans since 600 B.C. The knob is a fleshy protrusion of the stem that emerges totally above ground and is utilized as a vegetable. It is a cole crop that produces a delicious vegetable. It contains a significant amount of vitamins and minerals. According to Islam *et al.* (2020), *knol-khol* has 93.0 g of water, 29.0 g of calories, 6.6 g of carbohydrates, 2.0 g of proteins 1 g of fiber, and ash each per edible stem weighing 100 g. Besides this, it also contains potassium (372.0 mg), vitamin C (66.0 mg), phosphorus (51.0 mg), calcium (41.0 mg), vitamin A (20.0 mg), sodium (8.0 mg), iron (0.5 mg), thiamin (0.06 mg), riboflavin (0.04 mg), niacin (0.03 mg). Isothiocyanates, sulforaphane, and indol-3-carbinol are phytochemicals also found in *knol-khol* (Chauhan *et al.* 2012). The bioactive

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chemicals such as sulforaphane and isothiocyanates, aid in the formation of protective enzymes in our bodies and strengthen our immune system (Kurilich *et al.* 2002). Different medicinal properties of *knol-khol* include cancer, asthma, acidosis, heart problems, cholesterol, indigestion, skin problems, weight loss, muscle and nerve functions, and so on (Singh Chauhan *et al.* 2016).

Different factors governing the production of *knol-khol* include quality seeds, fertilizers, variety, plant spacing, and crop management practices. The reason for the low actual yield in comparison to the potential yield due to a lack of knowledge about its nutritional worth and technique of production. This can be overcome by implementing current agronomic practices including hybrid varieties, planting methods, controlled irrigation, and improved soil nutritional status through balanced fertilizer treatment. The use of all three major nutrient sources, inorganic, organic, and biofertilizers, is a key component of sustainable agriculture. These three components provide numerous benefits, including increased availability of various critical nutrients, improved physical, chemical, and biological qualities of the soil, and increased moisture-holding capacity (Kumar *et al.* 2018; Shah *et al.* 2018). Cole crops respond strongly to the main necessary nutrients such as NPK in terms of growth and yield (Thompson & Kelly, 1957).

Plants need sustenance in the form of proper dosages of NPK for growth and development. Nitrogen is included in amino acids, proteins, chlorophyll l, nucleic acids, and pigments (Sadak *et al.* 2015). Phosphorous has a key role in photosynthesis, respiration, cell division, cell enlargement, energy storage, and transfer (Arain *et al.* 2017)P, K, B, Cu, Fe, Mn, and Zn. Physiological processes like photosynthesis, nitrogen metabolism, sugar translocation, enzyme activation, stomata opening, etc. were catalyzed by potassium (A. R. Kumar *et al.* 2006). Again, the use of organic manures offers several advantages over inorganic manures in the production of crops. Minimization of soil erosion, enhancement of water retention capacity, and improvement of soil physiochemical and biological properties are the result of organic matter. Organic matter contains a significant number of micronutrients in addition to nitrogen, phosphorous, potassium, and sulfur. Knol-khol is a short-lived crop that should be grown with easily soluble organic manure. Organic manure plays a key role in soil moisture conservation. Moisture availability also aids in the uptake of other nutrients by the plants. Nitrogen fertilizer may also be available to the plants due to the abundant soil moisture. In this approach, organic manure aids nitrogen fertilizer uptake (Islam *et al.* 2020).

In general, using organic and inorganic sources of nutrients together provides a better status than using each one separately due to their interacting benefits. The useful organic and inorganic fertilizers have sustained greater levels of productivity and long-term soil fertility (Shah *et al.* 2018). Thus, the experiment was conducted to examine the effect of organic manures, fertilizers, and their interactive advantages on the growth and yield of Knol-khol in the Terai condition of Nepal. The use of organic manures and fertilizers may boost the yield of Knol-khol which is nutritive and cheap.

MATERIALS AND METHODS

1. Research location

The field experiment was conducted at the Institute of Agriculture and Animal Science (IAAS), Rupandehi, Nepal, from December 2022 to February 2023. It is located at 79 Masl and has the coordinates of 27^{0}40′60″ N, 83^{0}25′0″ E.

Table 1: Monthly average minimum and maximum temperature of study site from December 2022 to February 2023

Year	Month	Average minimum temperature (^{0}C)	Average maximum temperature (^{0}C)
2022	December	11.78	22.44
2023	January	8.9	18.59
2023	February	11.05	25.35

2. Experimental details

Randomized complete block design (RCBD) was used in the experiment with three replications. The entire field was divided into three blocks, with eight treatments in each. Knolkhol "White Viana variety" seedlings were produced in the nursery bed of the IAAS Horticulture farm on a flat-bed system.

About one-month-old seedling of *knol-khol* cv. White Viana was transplanted in flat beds according to an experimental design in early December 2022. Each plot measured 2.5m × 2.5m in size. The distance between the two plots was 50cm, while the distance between the two blocks was 1 meter.

Table 1: The doses of manures and fertilizers applied in the experiment

Treatments	Dose (per hectare)	Dose (Per Plot)
T_1	FYM (20 ton ha^{-1})	FYM (12.5 kg)
T_2	FYM (15 ton ha^{-1})	FYM (9.375 kg)
T_3	PM (20 ton ha^{-1})	FYM (12.5 Kg)
T_4	Half of Recommended dose of fertilizers (60:40:45kg NPK ha^{-1})	Urea (81.52g) + DAP (54.34g) + MOP (41.67g)
T_5	FYM (15 ton ha^{-1}) + Half of Recommended dose of fertilizers (60:40:45kg NPK ha^{-1})	FYM (9.375 kg) + Urea (81.52g) + DAP (54.34g) + MOP (41.67g)
T_6	FYM (10 ton ha^{-1}) + Half of Recommended dose of fertilizers (60:40:45kg NPK ha^{-1})	FYM (6.25 kg)+ Urea (81.52g)+ DAP (54.34g)+ MOP (41.67g)
T_7	PM (15 ton ha^{-1}) + Half of Recommended dose of fertilizers (60:40:45kg NPK ha^{-1})	FYM (9.375 kg) + Urea (81.52g) + DAP (54.34g) + MOP(41.67g)
T_8	Control	0 kg FYM + 0 kg PM + 0 Kg NPK

3. Raising of seedlings

The *knol-khol* saplings were nurtured with extra care at the IAAS Horticulture farm in Paklihawa. The seedbed soil was plowed, making it loose and friable. The seedbed was sun-dried to prevent damping off disease infection. Shading, weeding, mulching, and light watering were done regularly to maintain a favorable environment for the production of healthy seedlings.

4. Land preparation and fertilization

The land was plowed with a power tiller until it had a fine tilth. The area was cleared of weeds and stubbles, and large clods were broken up into little bits. The entire amount of FYM, PM, DAP, and MOP, as well as half dose of the urea, were applied as a basal dose in the field one day before transplanting, while two splits of urea were applied 20 and 30 days after transplanting (DAT), respectively. A spade was used to mix the applied fertilizer thoroughly with the soil.

Transplanting of seedlings

On December 23, 2022, seedlings were transplanted. 4 weeks old seedlings that were healthy and uniform in size were used for transplanting. To reduce seedling root damage, seed beds were moistened before removing the seedlings. Transplanting was done in the evening at a spacing of 50cm × 50cm, with 25 plants per plot. After transplantation, prompt watering was done on seedlings. Regular care and watering were done every day for around 10 days until the seedlings were established. Two lines of border plants were also planted on either side to fill up the gaps.

5. Crop management and harvesting

Gap filling was done as needed. After 15, 30, and 45 days after transplanting hand weeding was performed to keep the plants weed-free during the entire growth period. Light irrigation was done in the evenings using a watering can on each alternative day. When the edible section of the plants had grown to maturity, the *knol-khol* was collected.

6. Data Collection

(a) Phonological characters

Tagging of plants was done in five randomly selected sample plants, excluding the border plants in each plot to collect the data. In every 15-day interval, plant height and number of leaves were measured till harvesting. The knob size was measured using a rope and a centimeter scale. Canopy cover was estimated in centimeters by mean canopy coverage of an individual in multiple directions. During harvesting, leaf length and leaf breadth (from three points on each leaf, top, mid, and bottom) were measured in each plant. The fresh weight of the plant's edible section was measured in both grams and kilograms. With the sharp knife, selected knobs were sectioned vertically from mid-position, and the depth was measured with a scale.

(b) Biological yield, economic yield, and Harvest index

The biological yield of the sample plant was determined by weighing the whole plant by uprooting it, the economic yield as the weight of the edible sections of the sampled plants in a plot, and the yield per hectare as the weight of the whole plants of plots in t ha^{-1}.

$$\text{Harvest index} = \frac{\text{Economic yield (t ha}^{-1})}{\text{Biological yield (t ha}^{-1})} \times 100\%$$

7. Statistical analysis

Data were analyzed statistically following analysis of variance (ANOVA) with the help of the R (Version: 4.3.1) program. The mean comparison was done using the least significant difference (LSD) at a 5% level of probability.

RESULTS AND DISCUSSION

The purpose of this study was to evaluate how different organic manures and fertilizers affect the growth and yield of *knol-khol*. The major and combined effects of organic manures and fertilizers on *knol-khol* growth and yield have been shown and addressed here.

1. Effect of organic manures and fertilizers on growth parameters of Knol-khol

(a) Plant height

Statistically significant variation was observed in plant height with the application of different combinations and sole application of fertilizers and manures at 15, 30, 45, 60, 75, 95, and 105 days after transplanting. T_7: PM (15 ton ha^{-1}) + Half of Recommended dose of fertilizers (60:40:45 kg NPK ha^{-1}) had the highest plant height (27.21 cm) after 105 DAT, followed by T_5: FYM (15 ton ha^{-1}) + Half of Recommended dose of fertilizers (60:40:45kg NPK ha^{-1}) which had the plant height of 25.75cm, while T_8 (control) had the lowest plant height of 19.30 cm (Fig. 1).

Plant height is determined by a variety of elements such as genetic makeup, nutritional availability, environment, soil, and so on (Islam *et al.* 2020). According to the findings of this study, the interactive effect of organic manures and inorganic fertilizers provided appropriate accessible plant nutrients for healthy vegetative growth of the plants, which eventually affected plant height. The interactive effect of fertilizers gives maximum plant height in cauliflower (Moratagi *et al.* 2022). Singh B *et al.* (2019) reported increased plant height of garlic with an application of organic manures after 60 and 90 DAP of crop. Similarly, the application of N, P, S, and Zn results in an increase plant height of garlic as reported by (Assefa *et al.* 2015). The highest plant height was recorded in radishes with the application of organic and inorganic fertilizer (50% dose of N through chemical fertilizer + 50% dose of N through poultry manure) as reported by (Basnet *et al.* 2021). Poultry manure contains several micro and macro-nutrients and has faster nutrient-releasing capacity while major nutrients are provided by NPK applied, it may lead to increased nutrient availability and increased growth of plant may occur. This may be the possible reason behind an increase in plant height with the combined application of poultry manure and 50% NPK.

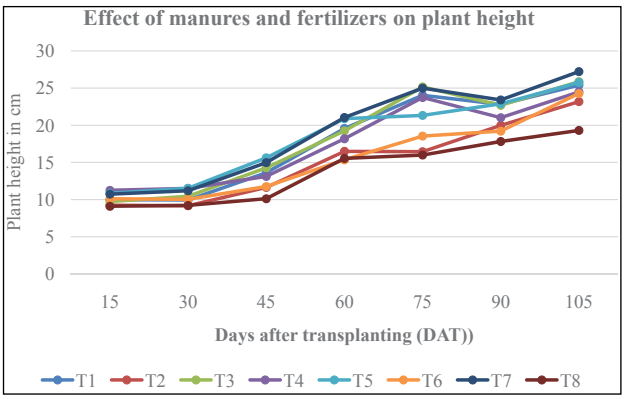

Fig. 1: Effect of organic manures, fertilizers, and their combination on plant height

(b) Number of leaves

Similarly, the application of organic manures, fertilizers, and their mixture results in variation in the number of leaves observed in Knol-khol 15, 30, 45, 60, 75, 90, and 105 DAT. The maximum number of leaves (17.4) followed by (15.8) was observed in T_3: PM (20 ton ha^{-1}) and T_4: Half of the Recommended dose of fertilizers (60:40:45kg NPK ha^{-1}) respectively while the minimum number of leaves (13.23) was observed in T_8 (control) followed by T_2 (14.45) after 105 DAT (Fig. 2).

Increased vegetative characteristics of cabbage using poultry manure over other fertilizer treatments were reported (Moyin-jesu, 2015). Different studies in the past yielded the maximum number of leaves in a full dose of NPK followed by poultry manures due to readily available nutrients. Poultry manure decomposes quickly and releases all crucial nutrients for the crop (Boateng *et al.* 2006). Because of this quality of poultry manure, T_3 crops received nutrition quickly, and they may have had the highest plant height. The application of poultry manure resulting greatest number of leaves may be due to the availability of a sufficient amount of macro and micronutrients which may boost the growth of leaves in *knol-khol*.

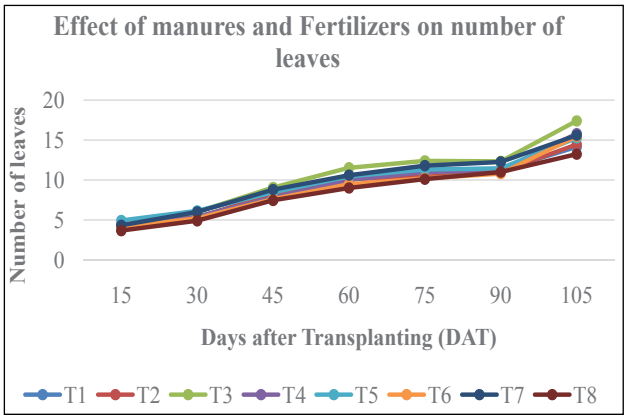

Fig. 2: Effect of organic manures, fertilizers, and their combination on the number of leaves

(c) Leaf length, leaf width, and crown spread

The variation in length and width of leaves and crown spread was observed at 105 DAT. The highest leaf length (23.74 cm), leaf width (10.53 cm), and crown spread (50.88 cm) were observed in T_7: PM (15 ton ha^{-1}) + Half of Recommended dose of fertilizers (60:40:45kg NPK ha^{-1}) while minimum leaf length (17.7 cm), leaf width (8.19 cm) and crown spread (34.47 cm) was observed in T_8 (control) as shown in Fig. 3.

The combined effect of different manures and fertilizers on plant leaf length, leaf width, and crown spread was shown to be considerable. This could be because of the presence of all three key components in a correct amount and the availability of micronutrients from poultry manure which results in increased vegetative growth of the plants. When cultivated in the early *rabi* season, the combined effect of poultry manure, cow dung, or vermicompost resulted in the greatest spread of plant canopy coverage reported by (Krupkiin *et al.* 1994; Steffen *et al.* 1994).

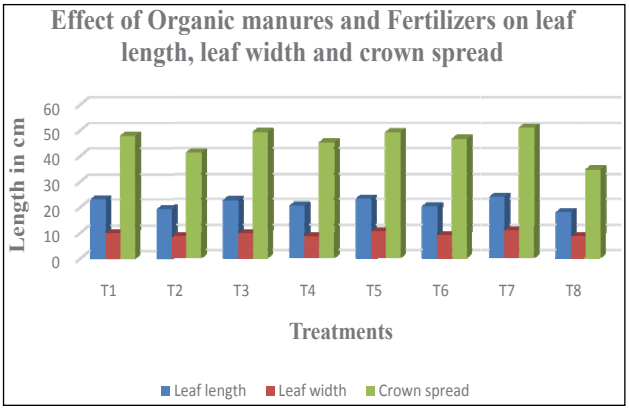

Fig. 3: Effect of organic manures, fertilizers, and their combination on leaf length, leaf width, and crown spread

(d) Knob size and knob depth

The effect of knob size and knob diameter shows variation with the application of manures, fertilizers, and their combination. After 105 DAT, the highest knob size (7 cm) and knob diameter (20.06 cm) were observed in T_4: Half of the Recommended dose of fertilizers (60:40:45kg NPK ha^{-1}) and T_7: PM (15 ton ha^{-1}) + Half of the Recommended dose of fertilizers (60:40:45kg NPK ha^{-1}) respectively. The minimum knob size (5.32 cm) and knob diameter (14.47 cm) were observed in T_8 (control) as presented in Fig 4. Because *knol-khol* is a short-lived, high-feeding crop, it requires readily available nutrients (Islam et al., 2020). Application of NPK provides major nutrients readily which may be the reason to increase knob size and knob depth.

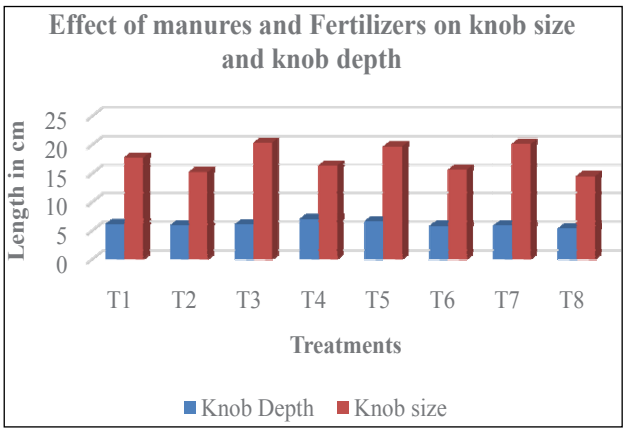

Fig. 4: Effect of organic manures, fertilizers, and their combination on knob size and knob depth

Table 2: Effect of organic manures, fertilizers, and their combination on economic yield, biological yield, and harvest index

Treatments	Economic Yield (g)	Biological Yield (g)	Economic Yield per hectare (tha^{-1})	Biological Yield per hectare (tha^{-1})	Harvest Index (%)
T_1	230.67±31.30^{d}	306.89±31.30^{c}	9.23±1.25^{d}	12.28±1.25^{c}	72.80±2.35^{b}
T_2	193.33±32.40^{de}	276.58±32.40^{cd}	7.73±1.30^{de}	11.06±1.30^{cd}	67.38±3.31^{c}
T_3	300.67±17.70^{c}	357.53±17.70^{b}	12.03±0.71^{c}	14.30±0.71^{b}	83.93±0.78^{a}
T_4	274.33±51.50^{c}	398.00±51.50^{b}	10.97±2.06^{c}	15.92±2.06^{b}	66.27±3.80^{c}
T_5	428.00±40.20^{a}	527.55±40.20^{a}	17.12±1.61^{a}	21.10±1.61^{a}	80.11±1.37^{a}
T_6	347.33±38.00^{b}	517.33±38.00^{a}	13.89±1.52^{b}	20.69±1.52^{a}	65.45±2.30^{c}
T_7	403.00±40.00^{a}	538.56±40.00^{a}	16.12±1.60^{a}	21.54±1.60^{a}	73.86±1.80^{b}
T_8	164.00±37.70^{e}	237.33±35.80^{d}	6.56±1.51^{e}	9.49±1.43^{d}	66.67±5.56^{c}
LSD (p≤ 0.05)	40.43***	41.26***	1.62***	1.65***	5.40***
CV%	7.89	5.96	7.89	5.96	4.21
Grand Mean	292.67	394.97	11.71	15.80	73.19

Note: *LSD= Least Significant Difference, CV= Coefficient of Variations, significant codes: *** = significant at P≤ 0.001. Treatments means are separated by least significant difference (LSD) and the columns are represented by the same letter(s) and are non-significantly different from each other at a 5 % level of significance.*

2. Effect of organic manures and fertilizers on yield parameters of *knol-khol*

(a) Economic yield, Biological yield, and Harvest index

The effect of different manures, fertilizers, and their combination on the economic yield of sample plants and economic yield per hectare showed statistically significant variation. The highest marketable yield (428 g) and marketable yield per hectare (17.12 t ha^{-1}) was observed in T_5: FYM (15 ton ha^{-1}) + Half of the Recommended dose of fertilizers (60:40:45kg NPK ha^{-1}) while the minimum marketable yield (164 g) and marketable yield per hectare (6.56 t ha^{-1}) was observed in T_8 (control) presented in Table 2. Similarly, statistically significant variation was observed among biological yield and biological yield per hectare. The highest biological yield (538.56 g) and biological yield per hectare (21.54 t ha^{-1}) were observed in T_7: PM (15 ton ha^{-1}) + Half of the Recommended dose of fertilizers (60:40:45kg NPK ha^{-1}) while minimum biological yield (237.33 g) and biological yield per hectare (9.49 t ha^{-1}) were observed in T_8 (control) presented in Table 2.

The combination of manures and fertilizers promotes photosynthetic efficiency and photosynthate translocation from source (leaves) to sink (knob) (Singh *et al.* 2023). The increased yield of knol-khol due to the application of poultry combined with NPK may be due to the reason that all thirteen necessary plant nutrients, namely nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), manganese (Mn), copper (Cu), zinc (Zn), chlorine (Cl), boron (B), iron (Fe), and molybdenum (Mo), can be found in sufficient quantities in poultry manure (Vale & Road, 1997). Poultry manure is significantly higher in critical plant nutrients and organic matter composition than other animal manures as solid and liquid excreta are excreted without loss of urine in poultry manure (Ewulo, 2015). Improvements in soil Physical and chemical with the application of poultry manure were observed (Adekiya *et al.* 2020).

Combined application of different manures and fertilizers treatments were found to be non-significant in the case of harvest index (Table 2). The maximum (83.93%) and minimum (65.45%) harvest index was observed in T_3: PM (20 ton ha^{-1}) and T_6: FYM (10 ton ha^{-1}) + Half of the Recommended dose of fertilizers (60:40:45kg NPK ha^{-1}) respectively.

CONCLUSION

From the yield point view, the "White Viana" variety of *knol-khol* performed well with the application of PM (15 ton ha^{-1}) + Half of the Recommended dose of fertilizers (60:40:45kg NPK ha^{-1}). The overall performance of *knol-khol* under the combined application of organic and inorganic fertilizers was

observed statistically significant. Thus, integrated nutrient management can be considered beneficial for the growth and yield of *knol-khol*. Further investigations will be needed to confirm whether organic manure alone or a full dose of NPK or their combination will increase the yield under different agroecological regions of Nepal.

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