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RESEARCH ARTICLE
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Organic and inorganic fertilizers on growth and yield of *Vigna radiata* L. sown after wheat crop in Nawalparasi West, Nepal

Fertilizantes orgánicos e inorgánicos en el crecimiento y rendimiento de *Vigna radiata* L. sembrada después del cultivo de trigo en Nawalparasi West, Nepal

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Abstract

The purpose of this study is to know the effect of different organic and inorganic fertilizers on the growth and yield of mung beans cultivated after the harvest of wheat in the Nawalparasi district of Nepal. An experiment was carried out at Sarawal rural municipality, Nawalparasi West district, Lumbini Province during the summer season of 2023. In this experiment, five treatments were used. The treatments included: T1: Control, T2: NPK (0:20:20 kg.ha^{-1}), T3: Recommended NPK dose (20:20:20 kg.ha^{-1}), T4: Farm Yard Manure(FYM) (5 t.ha^{-1}), and T5: Wheat residue (3 t.ha^{-1}) incorporation. The experiment was laid out in a Randomized Complete Block Design to the above five treatments which were replicated four times with an area of each plot 2.4 m^2. During this study period, the highest temperature recorded was 42.7 °C and the minimum temperature was 26 °C. Data on plant growth parameters like plant height, number of leaves, and yield parameters were measured. From the results, it was found that growth parameters like plant height at 15, 45, and 60 DAS and number of leaves at 60 DAS were significantly influenced by fertilizers treatment. Similarly, all the yield parameters like pods per plant, seeds per pod, 1000-grain weight, seed yield, and biological yield were significantly influenced by different fertilizers. All parameters showed better performance at NPK (20:20:20 kg.ha^{-1}). Major growth parameters were highest at NPK (20:20:20 kg.ha^{-1}) and lowest at control. Pods per plant, seeds per pod, 1000-grain weight (TGW), and harvest index were also higher in plots where the recommended dose of NPK fertilizer was applied. The maximum seed yield (0.71 t.ha^{-1}) was found in NPK (20:20:20 kg.ha^{-1}) than other treatments. Similarly, the harvest index of mung bean was the highest (25.39 %) in NPK (20:20:20 kg.ha^{-1}) and the lowest in control (22.41 %). This concludes that the performance of major growth parameters and yield parameters were better under the recommended dose of NPK (20:20:20 kg.ha^{-1}) fertilizer resulting in higher yield.

Keywords: *Mungbean, Fertilizers, Growth, Yield, Nepal*

Resumen

El propósito de este estudio es conocer el efecto de diferentes fertilizantes orgánicos e inorgánicos sobre el crecimiento y rendimiento de frijol mungo cultivado después de la cosecha de trigo en el municipio rural de Sarawal, distrito de Nawalparasi Oeste, provincia de Lumbini, durante la temporada de verano de 2023. En este experimento se utilizaron cinco tratamientos. Los tratamientos incluyeron: T1: Control, T2: NPK (0:20:20 kg.ha^{-1}), T3: Dosis recomendada de NPK (20:20:20 kg.ha^{-1}), T4: Estiércol de granja (FYM) (5 t.ha^{-1}), y T5: Incorporación de residuos de trigo (3 t.ha^{-1}). El experimento se organizó en un diseño de bloques completos aleatorizados para los cinco tratamientos mencionados, que se repitieron cuatro veces con una superficie de 2.4 m^2 en cada parcela. Durante el periodo de estudio, la temperatura máxima registrada fue de 42.7 °C y la mínima de 26 °C. Se midieron los parámetros de crecimiento de la planta, como la altura, el número de hojas y el rendimiento. De los resultados se desprende que los parámetros de crecimiento como la altura de la planta a los 15, 45 y 60 DAS y el número de hojas a los 60 DAS se vieron significativamente influidos por el tratamiento con fertilizantes. Del mismo modo, todos los parámetros de rendimiento como vainas por planta, semillas

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por vaina, peso de 1000 granos, rendimiento de semillas y rendimiento biológico se vieron significativamente influenciados por los diferentes fertilizantes. Todos los parámetros mostraron un mejor rendimiento con NPK (20:20:20 kg.ha^{-1}). Los principales parámetros de crecimiento fueron mayores con NPK (20:20:20 kg.ha^{-1}) y menores con el control. Las vainas por planta, las semillas por vaina, el peso de 1000 granos y el índice de cosecha también fueron mayores en las parcelas en las que se aplicó la dosis recomendada de fertilizante NPK. El máximo rendimiento de semillas (0.71 t.ha^{-1}) se encontró en NPK (20:20:20 kg.ha^{-1}) que en otros tratamientos. Del mismo modo, el índice de cosecha de frijol mungo fue el más alto (25.39 %) en NPK (20:20:20 kg.ha^{-1}) y el más bajo en el control (22.41 %). Se concluye que el rendimiento de los principales parámetros de crecimiento y los parámetros de rendimiento fueron mejores bajo la dosis recomendada de fertilizante NPK (20:20:20 kg.ha^{-1}) resultando en un mayor rendimiento.

Palabras clave: *Frijol mungo, Fertilizantes, Crecimiento, Rendimiento, Nepal*

1. Introduction

Wheat is a widely cultivated cereal grain that is used as a staple food worldwide. It is also known as the "king of cereals". It is a major cereal crop after rice and maize. It is widely grown in Terai, Inner Terai, and Mid-hills of Nepal. It is cultivated in an area of 716 978 ha with a total production of 2 144 568 t (Ministry of Agriculture and Livestock Development [MoALD], 2023). With the availability of hybrid and high-yielding varieties all around the country, the rice-wheat cropping system is gaining more popularity. Even though the rice-wheat system is an unavoidable cropping pattern for food security in Asia, there has been evidence of sustainability concerns associated with diverse expressions of the system.

The majority of grain legume's area and production is confined to Terai and the Inner Ierai and winter legumes contribute the major share in area and production. Among different legumes, green gram (mung bean) including other minor legumes is cultivated in Nepal in an area of 334 550 ha and the production is 408 371 t (MoALD, 2023). Mung bean is a plant of height 25 cm - 125 cm having a well-developed root system for nitrogen fixation. Mung bean is a short-duration, warm-season grain legume adapted to tropical and subtropical conditions. It is widely popular as a nutritionally rich pulse crop in Nepal. Globally, India is the leading producer of mungbean. Because of its excellent nutritional value, it is becoming more and more well-known in Nepal as a potential legume. For mung bean production to be successful and profitable, nutrient control is essential (Dhakal, 2020)**.** Lack of high-quality seeds for improved and short-duration varieties, growing mung beans in less fertile soil with minimal inputs, biotic and abiotic stresses, poor intercultural operations, unscientific post-harvest handling, improper storage, and an outbreak of seasonal pests and diseases are some of the reasons for low mung bean yield in Nepal (Bam et al., 2022).

In Nawalparasi West district, farmers follow a wheat-fallow-paddy system, leaving much of the arable land fallow for over two months. This fallow duration can be utilized by cultivating short-duration summer mung bean and import of mung bean can be decreased due to the low mung bean production in Nepal, mostly imports from India. The wheat-fallow-paddy system depletes soil fertility, raising sustainability concerns so the soil fertility condition can be improved by utilizing the nitrogen-fixing characteristic of mung bean (Zheng et al., 2023). As, wheat and paddy are nutrient-intensive, reducing the soil's nutrient reserves and impacting future crop yields (Lamsal & Khadka, 2019). Mung bean planted between rice and wheat rotations improves soil fertility and rice productivity by as much as 25 percent (Khanal, 2013; Pratap et al., 2021). Because of its short life cycle, mung bean can withstand water scarcity conditions so it may be cultivated in both spring and summer cropping systems (Raina et al., 2016). Farmers increasingly rely on chemical fertilizers, which are expensive and often unavailable when needed, further decreasing production. Additionally, wheat residue management poses challenges, with many farmers burning residues, causing air pollution and nutrient loss (Porichha et al., 2021)**.** Wheat residue can be managed by utilizing it as a fertilizer (Fang et al., 2019). Utilizing the fallow period for mung bean cultivation, a short-duration crop, can mitigate these issues by growing and harvesting it quickly within two months. On the contrary, there has not been significant research on the sustainability aspects of RWCS, the performance of mung bean cultivation under different fertilization conditions, and its effect on soil fertility in Nawalparasi West District, Nepal. This paper aims to identify the effects of different organic and inorganic fertilizers on the growth and yield parameters of mung bean and the suitability of its production in this area.

2. Materials and Methods

2.1 Description of research site

2.1.1 Location

The experiment was carried out in the farmer's field at Sarawal rural municipality, Nawalparasi West district, Lumbini Province, Nepal from March 2023 to June 2023. It is located at an elevation of 111 meters above mean sea level. Its geographical location is 27° 30' 17" north latitude and 83° 43' 54" east longitude.

2.1.2 Weather status of the study area

Nawalparasi West features a tropical and sub-tropical climate. Hot weather dominates from April to October, transitioning to milder temperatures in October, November, and March. The winter period, encompassing December, January, and February, is notably cold. The area encounters pre-monsoon and monsoon seasons extending from late May to late September, marked by substantial rainfall. Summer peak temperatures can soar to 44.2 °C, while the coldest recorded winter temperature stands at 14.7 °C. During this study period, the highest temperature recorded was 42.7 °C and the minimum temperature was 26 °C.

2.1.3 Physio-chemical properties of the experimental soil

Soil samples were randomly taken from each of the four corners and from a central experimental plot that was between 0 cm and 15 cm below the surface to examine the basic physical-chemical characteristics. Soil analysis of a composite sample collected was done at Lumbini Agro Environment Lab Pvt. Ltd. In the analysis, the pH of the soil was tested by probe method, and soil organic matter was determined by the Walkley and Black method. Similarly, the quantity of nitrogen, phosphorous, and potassium in the soil was determined by the Kjeldahl method, Modified Olsen's method, and the Ammonium acetate method respectively (Table 1).

2.2 Experiment details

- Name of crop: Mung bean (*Vigna radiata* L.)
- Design: RCBD
- Variety: Pratikshya
- No. of treatments: 5
- Replication: 4
- Individual plot size: 2.4 m × 1 m = 2.4 m^2
- Spacing between plots = 0.4 m
- Spacing between replication = 1 m
- Method of sowing = Line sowing
- Sowing depth = 3 cm - 5 cm
- Row to row spacing = 30 cm
- Plant-to-plant spacing = 10 cm
- Number of plants in each plot = 80

2.3 Treatment Details and Layout

The experimental design was a Randomized Complete Block Design (RCBD) having five treatments that were replicated four times. The treatments used are presented in Table 2, Figure 1 and 2.

Table 1. Soil characteristics of the experimental field

S.N.	Parameters	Unit	Test method	Observed value
1	pH	-	Probe method	6.9
2	SOM (%)	%	Walkley and Black method	2.84
3	Nitrogen (%)	%	Kjeldahl method	0.168
4	Phosphorous	$Kg.ha^{-1}$	Modified Olsen's method	95.68
5	Potassium	$Kg.ha^{-1}$	Ammonium acetate method	403.2

Table 2. Treatment details used in research

Symbols	Treatment Property
T1	Control
T2	N0PK (0:20:20 $kg.ha^{-1}$)
T3	Recommended dose of NPK (20:20:20 $kg.ha^{-1}$)
T4	FYM (5 $t.ha^{-1}$)
T5	Wheat residue (3 $t.ha^{-1}$)

2.4 Field preparation, Treatment application, and Cultural practices

The land was prepared through plowing, cross-plowing multiple times, leveling, and removal of weeds and remnants of previous crops. The experimental plot was divided into smaller unit plots according to the experimental design described earlier. Mung bean seeds (Pratikshya variety) were sown at the rate of 1 5kg.ha^{-1} on 19th April 2023 (Khariff season). The sowing was done at a depth of 3 cm^{-5} from the ground surface. Before sowing, Farmyard Manure (FYM) was applied at 5 t.ha^{-1}. Chemical fertilizers were applied at 20:20:20 NPK kg.ha^{-1} (recommended dose) using Urea, Single Super Phosphate (SSP), and Muriate of Potash (MOP) as the basal dose. Another treatment (NPK) was conducted without nitrogen. Wheat stubble was also incorporated as a treatment. The fertilizers were thoroughly mixed into the soil by spading, and the unit plots were leveled again. Irrigation was applied uniformly across all plots. It was done after seed sowing to aid germination and during the flowering and pod development stages, which are critical for mung bean irrigation. Subsequent irrigations were carried out at 15-day intervals. Hand weeding was performed twice, at 20 and 40 days after sowing (DAS). Although insecticides or chemical treatments are generally recommended for pest and disease management, no such treatments were needed as there were no incidences of pests or diseases during the experiment.

2.5 Description of Variety

Pratikshya variety of mungbean is a recommended variety in Nepal with an average maturity duration of around 63 days. It has an average productivity of 0.686 t.ha^{-1}. Terai, chure hills, and mid hills are the recommended domain of this variety in Nepal.

2.6 Harvesting

The ripened pods were harvested by hand picking twice on 15th June and 29th June 2023. Plants were cut down to ground level. Each plot of harvested produce was packed individually. Grain and stover yields were recorded plot-wise and the yields were expressed in t.ha^{-1}.

2.7 Data Collection and Observations

The samples were collected from all plots of each replication of the experimental field. Five sample plants were taken from each plot excluding the border plants and tagged for data collection. Data were collected at 15, 30, 45, and 60 DAS. The sample plants from each plot were selected randomly. Ripe pods were picked twice and the sample plants were cut down to ground level before harvest and dried properly in the sun. The yield of grains and stover per plot was measured after being thoroughly cleaned and allowed to dry in the sun. Data was gathered based on the following parameters:

a. Number of leaves per plant

Several cotyledonous and trifoliate leaves were counted from the tagged plants of each plot. Data were taken at 15,

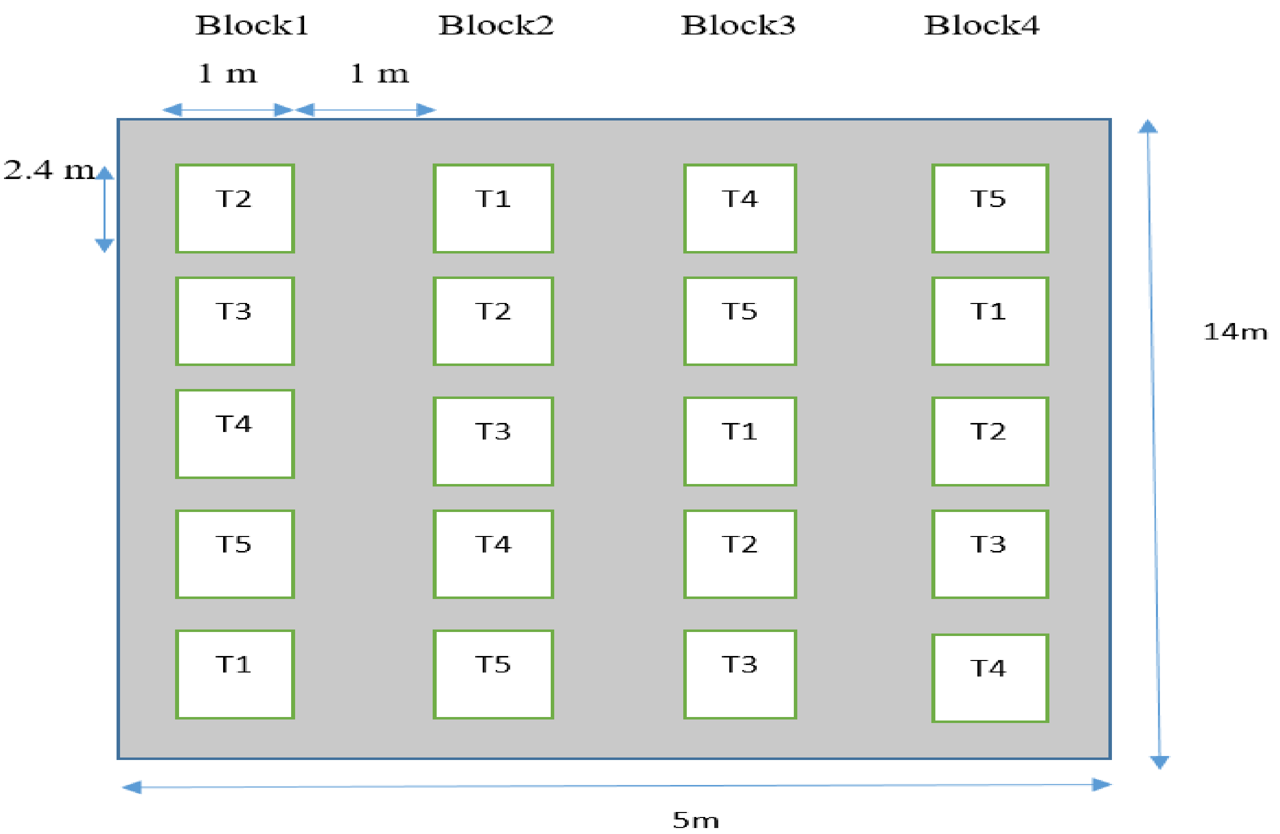

Figure 1. Layout of the experimental

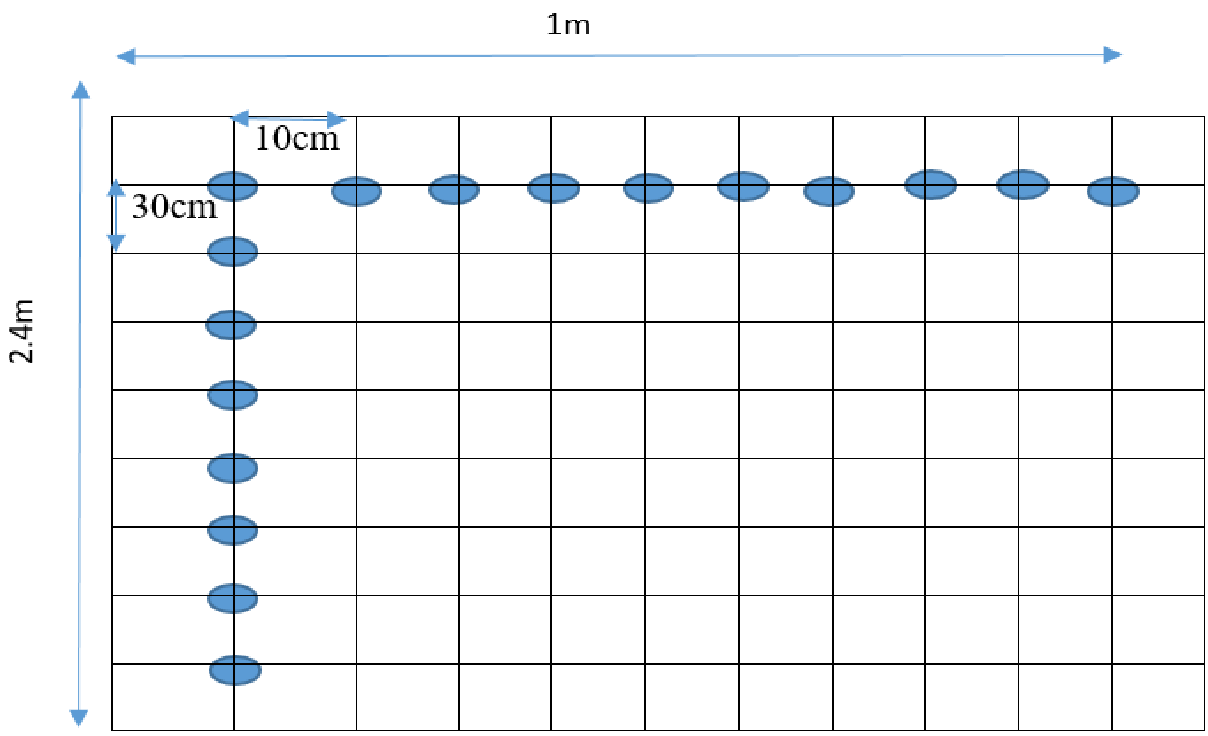

Figure 2. Layout of individual plot

30, 45, and 60 DAS. Then, the data was averaged to find the number of leaves per plant in each plot.

b. Plant height

The height of the plants was determined by measuring the distance from the ground level to the highest point of the canopy. Data on plant height were taken at 15, 30, 45, and 60 DAS. This measurement was taken for five randomly chosen plants within each plot, and the results were averaged to obtain a representative value for that specific plot.

c. Number of pods per plant

The total number of pods was counted per plant at the time of picking from the randomly selected five plants of each plot and averaged.

d. Number of seeds per pod

Seeds in pods of five randomly selected plants were counted at the maturity stage from each plot and averaged.

e. Thousand Grain weight

Thousand seeds were taken from each plot and weighed with the help of an automatic electronic balance.

f. Grain yield

Eight central rows were harvested to record the grain yield except for border plants. The crop was dried, threshed, cleaned and the final weight was taken. A sample of around 100 g was allocated from each net plot for oven drying and calculating moisture percentage. Using the net plot yields for each treatment, the grain yield per hectare was calculated.

A universal moisture meter was used to record the moisture percentage of the grain. Finally, grain yield will be adjusted at 0 % moisture using the formula suggested by Paudel (1995), and Shrestha et al. (2021).

$$\text{Grain yield (kg.ha}^{-1}\text{ at 0 \% moisture)} = \frac{(100-MC)\times plot\ yield(kg)\times 10000\ m^2}{(100-0)\times net\ plot(m^2)}$$

Where, MC is the moisture content of the grains.

g. Stover yield

After the harvest of pods from each plot then the haulm was dried and weighted to determine the haulm yield.

h. Harvest Index

The harvest index (HI) was calculated by dividing grain yield by the total dry matter yield as per the following formula.

$$\text{Harvest index} = \frac{Grain\ yield}{(grain + pod\ shell + haulm)yield} \times 100$$

2.7 Data Analysis

The collected data were first compiled in MS Excel and analyzed using R-studio to find out the significance of the difference among the treatments, analysis of variance was evaluated and the mean values of all the characters were separated by using Duncan's Multiple Range Test (DMRT). LSD test was carried out and the standard error of the mean was also determined.

3. Results and Discussion

3.1 Growth parameters

The effects of applying organic and inorganic fertilizers on different growth parameters like plant height and number of leaves per plant were observed at 15, 30, 45, and 60 DAS.

3.1.1 Plant height

The effect of the applied fertilizers (Table 3) on plant height was not found to be significantly different at 30 DAS whereas at 15 DAS the NPK (RDF) shows significantly higher plant height than other treatments. Similarly, at 45 DAS and 60 DAS also plant height was highest at the recommended dose of NPK fertilizer. Plant height of plant was better in the plot incorporated with wheat residue than control condition. The highest plant height was found to be 61.96 cm at NPK (RDF) and 45.53 cm was the lowest height at the control condition at 60 DAS which confirms with findings of (Achakzai et al., 2012) which shows that an increase in plant height with increasing Nitrogen application.

Table 3. Effect of different fertilizers on plant height of summer mung bean at Nawalparasi West, Nepal, 2023

Treatments	Plant height (cm)			
	15 DAS	30 DAS	45DAS	60 DAS
Control	3.54^{b}	7.77	30.34^{c}	45.53^{d}
N0PK (0:20:20 kg.ha^{-1})	3.73^{b}	8.51	32.69^{bc}	59.39^{b}
NPK (20:20:20 kg.ha^{-1})	4.23^{a}	9.05	38.91^{a}	61.96^{a}
FYM	3.52^{b}	8.20	35.33^{b}	57.54^{bc}
Wheat residue	3.47^{b}	6.71	29.38^{c}	55.51^{c}
LSD (0.05)	0.38	-	3.500	2.558
SEm (±)	0.06	-	0.507	0.3713
F-probability	**	ns	***	***
CV %	6.67	-	6.816	2.966
Grand mean	3.70	8.047	33.327	55.986

Note: the common letter(s) within the column indicates the non-significant difference based on the Duncan Multiple Range Test (DMRT) at 0.05 level of significance, *denotes <0.05, ** denotes <0.01, and *** denotes <0.001 level of significance. ns = non-significant, SEm = Standard error of mean, CV = Coefficient of variance, LSD = Least significant difference, DAS = Days after sowing.

3.1.2. Number of leaves per plant

The number of leaves (Table 4) was significantly affected by applying different fertilizers only at the later stage of the growth i.e. at 60 days. The maximum number of leaves per plant was found to be 27.61 in NPK (20:20:20 kg.ha^{-1})

condition while the lowest (24.23) in the control condition at 60 DAS. Plant height being a genetically controlled character is affected by the different types of fertilizers containing various levels of NPK and similar results are also explained by (Achakzai et al., 2012).

Table 4. Effect of different fertilizers on the number of leaves of summer mung bean at Nawalparasi West, Nepal, 2023

Treatments	Number of leaves per plant			
	15DAS	30DAS	45DAS	60DAS
Control	2.25	5.25	16.32^{b}	24.23^{e}
N0PK (0:20:20 kg.ha^{-1})	2.75	5.35	17.57^{ab}	26.78^{b}
NPK (20:20:20 Kg.ha^{-1})	2.75	5.55	18.41^{a}	27.61^{a}
FYM	2.50	5.42	17.28^{ab}	26.08^{c}
Wheat residue	2.50	4.73	16.48^{b}	25.05^{d}
LSD(0.05)	-	-	-	0.474
SEm(±)	-	-	-	0.069
F-probability	ns	ns	ns	***
CV %	-	-	-	1.185
Grand Mean	2.55	5.26	17.211	25.952

Note: the common letter(s) within the column indicates the non-significant difference based on the Duncan Multiple Range Test (DMRT) at 0.05 level of significance, *denotes <0.05, ** denotes <0.01, and *** denotes <0.001 level of significance. ns = non-significant, SEm = Standard error of mean, CV = Coefficient of variance, LSD = Least significant difference, DAS = Days after sowing.

3.2 Yield and Yield attributing parameters

Different yield and yield attributing parameters like the number of pods per plant, number of seeds per pod, thousand-grain weight (test weight), grain yield, biological yield, and harvest index of mung bean were measured after harvesting. The results of ANOVA, DMRT analysis, and LSD test on these yield and yield parameters are shown in Tables 5 and 6.

3.2.1 Number of pods per plant

Different fertilizers have significant effects (<0.05) on the number of pods. The number of pods per plant was significantly higher than the recommended fertilizer dose. There is no significant difference was found between T2 and T4 and also between T5 and T1. The maximum number of pods was found to be 32.4 which is quite similar to the findings of (Asaduzzaman et al., 2008).

3.2.2 Number of seeds per pod

As per the findings of Sadeghipour et al. (2010), the number of seeds per pod of mung bean was similar in the case of T2 and T3 but significantly different from the T1, T4, and T5. The highest number of seeds per pod was found to be 12.1 under T2 (20:20:20 NPK).

3.2.3 Thousand-grain weight/test weight (TGW)

TGW of mung bean under control and wheat residue incorporation were not significantly different but significantly (<0.001) differed in other treatments. 33.60 g was the highest TGW found under the NPK (20-20-20 kg.ha^{-1}) application and the lowest (27.68 g) was found under the control condition. These findings are almost in conformity with the findings of (Hussain et al., 2021).

Table 5. Effect of different fertilizers on yield of summer mung bean at Nawalparasi West, Nepal, 2023

Treatments	Pods/plant	Seeds/pod	TGW (g)
Control	20.65^{c}	8.08^{b}	27.68^{d}
N0PK (0:20:20 kg.ha^{-1})	24.6^{b}	11.53^{a}	33.02^{b}
NPK (20:20:20 kg.ha^{-1})	32.4^{a}	12.1^{a}	33.60^{a}
FYM	23.85^{b}	10.08^{ab}	31.74^{c}
Wheat residue	20.6^{c}	9.98^{ab}	27.93^{d}
LSD(0.05)	2.800	2.272	0.522
SEm(±)	0.406	0.329	0.0239
F-probability	***	*	***
CV %	7.442	14.252	1.101
Grand Mean	24.42	10.35	30.79

Note: the common letter(s) within the column indicates the non-significant difference based on the Duncan Multiple Range Test (DMRT) at 0.05 level of significance, *denotes <0.05, ** denotes <0.01, and *** denotes <0.001 level of significance. ns = non-significant, SEm = Standard error of mean, CV = Coefficient of variance, LSD = Least significant difference, DAS = Days after sowing.

3.2.4 Grain Yield

Each fertilizer used as a treatment in the experiment showed a significant difference in the effect on grain yield of the mung bean crop which is also similar to the findings of Ali et al. (2020). Grain yield was found to be highest under recommended NPK application followed by N0PK, FYM, wheat residue, and control condition serially. A Grain yield of 0.71 t.ha^{-1} was the highest among the fertilizers used in the experiment which is similar to the production potential of the Pratikshya variety of mung bean as stated by (Pokhrel et al., 2019).

3.2.5 Biological Yield

There is the significant difference in effect on biological yield was seen for the application of different fertilizers in the mungbean crop. The biological yield was calculated to be 2.80 t.ha^{-1} under NPK(RDF) condition. However, no significant difference in biological yield was found between wheat residue incorporation and control condition. Biological yields were significantly and positively affected by different fertilizer levels. This is in line with the findings of (Ali et al., 2020).

3.2.6 Harvest Index(HI)

From the data analysis (Table 6), the highest HI was 25.39 % in the case of NPK (20-20-20 kg.ha^{-1}) but there was no significant difference between the harvest index under NPK (20-20-20 kg.ha^{-1}) and N0PK (20-20-20 kg.ha^{-1}) conditions. Similarly, FYM and wheat residue also didn't show significantly different effects in the case of HI.

Table 6. Effect of different fertilizers on yield of summer mungbean, Nawalparasi West, Nepal, 2023

Treatments	Grain Yield ($t.ha^{-1}$)	Biological yield ($t.ha^{-1}$)	Harvest index
Control	0.27^{e}	1.32^{d}	20.67^{b}
N0PK (0:20:20 $kg.ha^{-1}$)	0.58^{b}	2.33^{b}	24.99^{a}
NPK (20:20:20 $kg.ha^{-1}$)	0.71^{a}	2.80^{a}	25.39^{a}
FYM	0.43^{c}	1.86^{c}	23.27^{ab}
Wheat residue	0.31^{d}	1.37^{d}	22.41^{ab}
LSD(0.05)	0.028	0.176	3.125
SEm(±)	0.004	0.03	0.45
F-probability	***	***	*
CV %	3.921	5.901	8.687
Grand Mean	0.461	1.937	23.347

Note: the common letter(s) within the column indicates the non-significant difference based on the Duncan Multiple Range Test (DMRT) at 0.05 level of significance, *denotes <0.05, ** denotes <0.01, and *** denotes <0.001 level of significance. ns = non-significant, SEm = Standard error of mean, CV = Coefficient of variance, LSD = Least significant difference, DAS = Days after sowing.

4. Conclusion

In this study, the yield of *Vigna radiata* was 0.71 $t.ha^{-1}$ under the recommended dose of chemical fertilizers. The character seeds per pod did not reach statistical significance. Growth and yield of mung bean were better under the application of the recommended dose of NPK (20-20-20 $kg.ha^{-1}$) than other fertilizers. Plant height and number of leaves per plant of mung bean were found to be significantly higher than the control condition. Similarly, yield parameters like the number of pods per plant, number of seeds per pod, and thousand-grain weight were better than in other treatments. This better performance of growth and yield parameters resulted in a higher grain and biological yield. Yield and growth parameters perform better under wheat residue incorporation than control conditions. So, wheat residue after wheat harvest can be utilized for better performance of mung bean crops if applied in higher doses.

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Conflict of interest

The authors declare no conflict of interest.

Funding declaration

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Author contribution

SB: Conceptualization, Methodology, Writing-Original draft, Data curation and analysis, Visualization. SS: Writing-Review and Editing. HNG: Supervision, Investigation, Writing- Review and Editing. NK: Conceptualization, Supervision.

Consent for publication

We humbly give consent for this article to be published.

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Appendix

Appendix 1: Mean square values of the number of leaves of mung bean after 15, 30, 45, and 60 DAS

Source of variance	df	No. of leaves			
		15DAS	30DAS	45DAS	60DAS
Replication	3	0.58333	0.01333	0.30494	0.3722
Treatment	4	0.17500	0.39422	2.89467	7.2257
Error	12	0.20833	0.24444	1.06541	0.0946

Appendix 2: Mean square values of plant height of mung bean after 15, 30, 45, and 60 DAS

Source of variance	df	Plant height(cm)			
		15DAS	30DAS	45DAS	60DAS
Replication	3	0.13330	7.0553	3.018	2.120
Treatment	4	0.39308	3.1343	60.076	159.284
Error	12	0.06113	2.5034	5.161	2.758

Appendix 3: Mean square values of the number of pods plant-1 of mung bean

Source of variance	df	No. of pods plant-1
Replication	3	2.435
Treatment	4	92.843
Error	12	3.303

Appendix 4: Mean square values of the number of seeds pod-1 of mung bean

Source of variance	df	Number of seeds pod-1
Replication	3	3.5793
Treatment	4	9.8350
Error	12	2.1760

Appendix 5: Mean square values of 1000-grain weight of mung bean

Source of variance	df	1000-grain weight(g)
Replication	3	1.877
Treatment	4	31.653
Error	12	0.115

Appendix 6: Mean square values of grain yield of mung bean

Source of variance	df	Grain yield
Replication	3	0.000938
Treatment	4	0.137443
Error	12	0.000326

Appendix 7: Mean square values of biological yield of mung bean

Source of variance	df	Biological yield
Replication	3	0.00705
Treatment	4	1.60513
Error	12	0.01307

Appendix 8: Mean square values of Harvest Index of mung bean

Source of variance	df	Harvest index
Replication	3	2.6425
Treatment	4	14.9140
Error	12	4.1138

Anexo 9: Glimpses of The Study

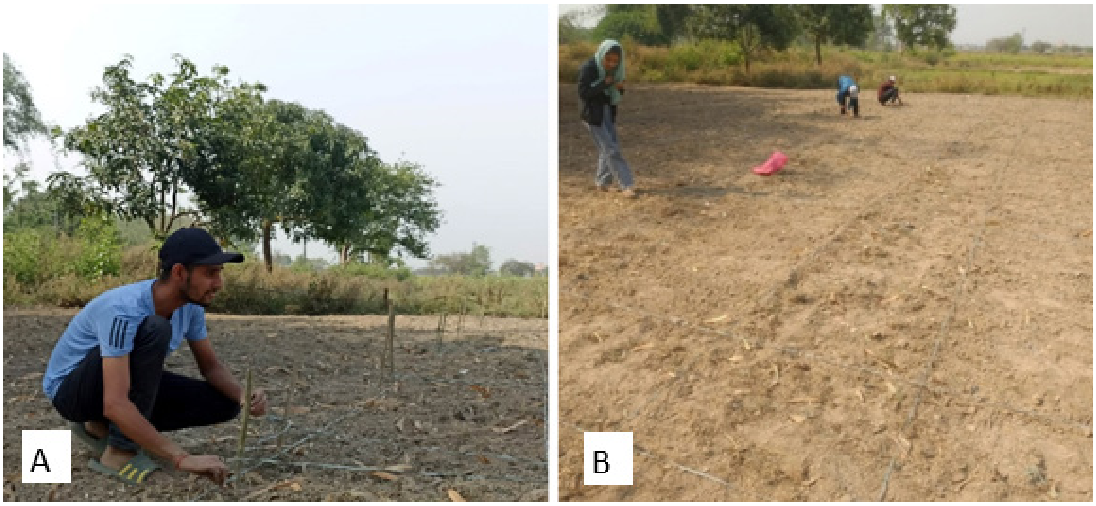

Figura 3: A y B) Preparation of experimental plot

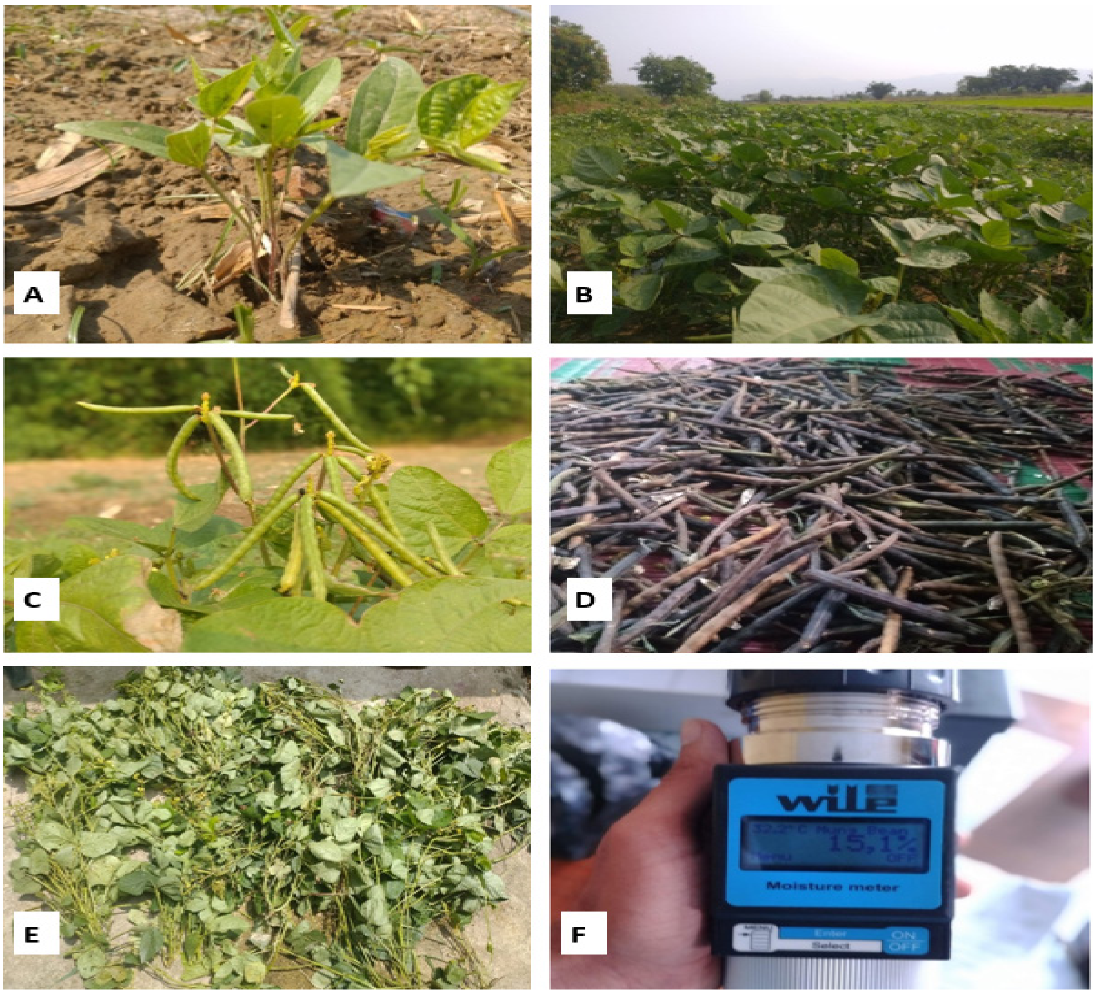

Figura 4: A) 15 días después del transplante (DAS), B) 30 DAS, C) 60 DAS, D) first picking, E) Final harvesting F) Moisture test