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Effect of Different Organic and Inorganic Fertilizers on Spring Rice Var. (Hardinath 1) Production in Rural Gorkha, Nepal

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ABSTRACT

The effect of different organic and inorganic fertilizers had a significant effect on the yield of spring rice. A field experiment was carried out to determine the effects of different organic and inorganic fertilizers on the yield of spring rice var Hardinath-1 at Siranchowk rural municipality-4, Gorkha during the spring season of 2021 with four replications and five treatments: T1[Recommended inorganic fertilizer Nitrogen, Phosphorous, and Potassium (@100:30:30 kg/ha)], T2[75% recommended inorganic fertilizer + 25% recommended organic fertilizer: i.e. (Farm Yard Manure (6 ton /ha)], T3(50% recommended inorganic fertilizer + 50% recommended organic fertilizer), T4(25% recommended inorganic fertilizer + 75% recommended organic fertilizer), and T5 (Recommended organic fertilizer) using simple Randomized Complete Block Design with 3*3 m of individual plot size. A biometrical observation like plant height (95.33 cm), and the number of tillers (340.75/ m^2) were found significantly highest on T2. Similarly, yield attributing characteristics like the number of effective tillers (315.75/m^2), several filled grains per panicle (150.25), and highest panicle length (25.06 cm) were also significantly highest on T2. The highest grain yield (8.27 ton/ha), straw yield (12.14 ton/ha), and harvest index (0.40) were also observed on T2. Total net return was found highest on T2: 287330 Nepalese Rupees(NPR) incurring the cost of fertilizer Rs NPR 18940 per hectare returning the gross return of NPR 268390 per hectare. In conclusion, T2 was the best combination of other biofertilizer combinations. So, the spring rice productivity can be enhanced via the adoption of 75% recommended inorganic fertilizer + 25% recommended organic fertilizer in fertilizer management practice at Chorkate, Gorkha.

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Introduction

Nepal is a landlocked country located between two huge countries: India and China. Agriculture is the mainstay of the Nepalese economy, the majority of people (65.6%) are directly involved in the Agriculture sector. Agriculture and forestry contributed 30.7% of the total Gross Domestic Product (GDP) in the country (Ministry of Finance, 2020). The majority of farmers are subsistence in nature and the self-sufficiency level of the country in grain production has not been met as the population is growing at a faster rate with increasing demand for food (Gairhe et al., 2018). Rice is the major food crop for about 3.5 billion people in the world and it is the staple food of estimated 2.4 billion people in Asia. In Nepal, rice occupies the first position in terms of area, production, and consumption. It supplies about 40% of the food calorie intake and contributes nearly 20% to the agricultural gross domestic product (AGDP) and almost 7% to GDP(CDD, 2015).

Rice (*Oryza sativa*) is the major staple crop of the Nepalese. More than 90% of global rice production and consumption account for the Asia region, and rice only accounts for more than 50% of the total calories of Nepalese people. The success of rice production is mainly dependent on the onset and duration of monsoon rain, which limits the increase in the yield of rice in Nepal. It ranks first among cereal crops in terms of area and production which account for about 50% of the area under food crop of 3.2 million ha (Joshi & Pandey, 2005). and it is grown in all agro-ecological zone of Nepal from Terai and inner terai, mid-hills to high hills of Nepal. The district with Gorkha municipality as its headquarters, covers an area of 3610 $km^2$and its altitude ranges from 228 to 8163 m from mean sea level. Out of 361000 ha. of land 55696 ha (15.43 %) is cultivable land and 46220 ha (12.80%) land is cultivated and lowland is 15052 ha (32.57%) of which 3016 ha (20.03%) is irrigated year-round and 12036 ha

(79.96%) is a rainfed area. Rice is an important cereal crop of the Gorkha district and farmers of the Gorkha grow rice two times a year i.e., spring season and rainy season.

It is a major source of employment, income, and food security for many rural households and provides more than 40% of the calories requirement of Nepalese people. The sustainable production of rice has been questioned due to intensive chemical fertilizer and pesticide use. There is increasing demand for chemical fertilizer in Nepal which was about 7,00,000 Metric Tons in the year 2016/17 (Panta, 2018). Nepal depends on foreign countries for fertilizer supply, which is creating negative trade (Trade et al., 2014). On the other side, paddy consumes the largest portion of the total amount of fertilizers sold in Nepal. Adverse effects on soil health, environment, and ecology are being noticed due to the excessive and imbalanced use of synthetic fertilizers. Persistent use of chemical fertilizers subverts the soil ecology, disrupts the environment, degrades soil fertility, and consequently shows harmful effects on human health and contaminates groundwater (Suhag, 2016). Long-term application of chemical fertilizers reduced soil pH value(Liu et al., 2010) which in turn reduces phosphate intake by crops, increases the toxic ion concentration in the soil, and inhibits crop growth. The unavailability of the recommended amount of fertilizer is a major problem among rice farmers. The adverse effect of these synthetic chemicals on human health and the environment can only be reduced by adopting new agricultural technological practices such as shifting from chemical-intensive agriculture to the use of organic inputs such as manure, biofertilizers, and biopesticides (Chandini et al., 2019). Siranchowk Rural Municipality of Gorkha district has a huge potential for rice production and it has shaped the agricultural and economic base of this area. Due to the proper facility of irrigation, it is possible to cultivate paddy even in the spring season. The unavailability and high cost of synthetic fertilizer have been a constraint for rice production in Nepal (Shrestha, 2010). Organic fertilizers can be a supplementary nutrient source for sustainable rice production (Hakeem et al., 2020). It maintains soil fertility and physical, chemical, and biological properties. Integration of biofertilizers along with a reduced dose of recommended synthetic fertilizers can maintain soil productivity and sustainable rice production. Thus, resolving the dependency on expensive and timely unavailable synthetic fertilizer. This research will come up with an economical and effective nutrient management practice enhancing sustainable rice production.

Materials and Methods

The experiment was conducted at Siranchowk Rural Municipality ward no.4, Gorkha. Gorkha is geographically located at 28.0524° N latitude and 84.5891° E longitude. The research was conducted in the Rice zone, PMAMP site. The soil was sandy loamy with acidic pH (5.5) and N_2 (0.04 %), P_2O_5 (45.8 kg/ha), K_2 O (108.7 kg/ha) and organic matter (0.9%) was low in the soil where research was carried out. Similarly, the physiochemical properties of FYM of cattle show that its pH was slightly acidic (5.9), N_2(0.3%), K_2O (0.8 kg/ha), P_2O_5 (0.3 kg/ha) was medium while moisture was high (49%).

The experiment was conducted in a Completely Randomised Block Design (RCBD) with 5 treatments (T1, T2, T3, T4, and T5) as shown in Table 1 below, and 4 replications using rice variety Hardinath-1 (recommended in Nepal in 2060 BS. It is recommended for terai, inner terai, river basin up to 800 masl). Data was entered and tabulated using MS-Excel, while analysis of variation and mean separation was done using R-Studio.

Number of grains/panicle and sterility %

The total number of filled grains was counted from randomly selected 10 panicles (panicles used for determining length). Total unfilled grains were counted and sterility percent was calculated using the following formula.

$$\text{Sterility percent} = \frac{\text{Number of unfilled grains per panicle}}{\text{Total number of grains per panicle}} \times 100$$

Grain and straw yield

The harvested crop was dried, threshed, cleaned, and again sun-dried and the final weight was taken with the help of electronic balance. Grains moisture in each plot was measured with a digital moisture meter and grain yield (GY) was calculated using the formula.

$$\text{GY} = \frac{(100-\text{MC}) \times \text{plot yield (kg)} \times 10000\,(\text{m2})}{(100-14) \times \text{net plot area (m2)}}$$

Where, GY is Gain yield (kg/ha) at 14% moisture and MC is the moisture content in the percentage of the grains. The straw yield was obtained by weighing the threshed straw of the net plot.

Harvest index (HI)

HI was computed as grain yield to the total dry matter yield as per the following formula. To obtain harvest index grain and straw yield were calculated at the same moisture level.

$$\text{HI\%} = \frac{\text{Grain Yield (Economic Yield)}}{\text{Total biomass yield (grain yield+straw yield)}}$$

Statistical analysis

The recorded data was systematically arranged in MS Excel, which was used for simple statistical analysis, and the construction of graphs and tables. The compiled data were subjected to Analysis of Variance (ANOVA) at a 5% significance level using R-studio software and significant data was subjected to DMRT for mean separation.

Table 1. Treatment details

S.N.	Treatment	Treatment details
1	T1	100% Inorganic Fertilizer (NPK)@ 100:30:30 kg ha-1
2	T2	75% (NPK)@ 75:22.5:22.5kg ha-1 +25% (FYM)@1.5t 3ha-1
3	T3	50% (NPK)@ 50:15:15kg ha-1 + 50% (FYM)@ 3t ha-1
4	T4	25% (NPK)@ 25:7.5:7.5kg ha-1 + 75% (FYM)4.5t ha-1
5	T5	100% Organic fertilizer (FYM)@ 6t ha-1

Results and Discussion

Biometric observations

Plant height

The combined application of different organic and inorganic fertilizers showed a significant effect on plant height as shown in Table 2 below. At 30, 45, 60, and 75 DAT, maximum plant height was observed on T2 (75% NPK + 25% FYM) which was 37.37 cm, 56.21 cm, 77.072 cm, and 95.33 cm, while minimum plant height was seen in T5 (100% FYM) which was 33.85cm, 52.63 cm, 70.01 cm, and 88.53 cm respectively at 30 DAT, T2 is statistically at par with T1, T3 and T4 and statistically different with T5, similarly, at 45DAT, T2 is statistically at par with T1 but highly significant with T3, T4, and T5. At 60 and 75 DAT, T2 is highly significant with T1, T3, T4, and T5. The increase in height of plants obtained by the use of chemical fertilizer could have been due to the highly stimulating effect of nitrogen on various physiological phases in cell division and cell elongation (Alim, 2012). A similar result was obtained by (Moe et al., 2017) from the application of 100% NPK plus organic manures.

Numbers of tillers

The combined application of different organic and inorganic fertilizers showed a significant effect on plant tillers as shown in Table 3. At 30, 45, 60 and 75 DAT, maximum tillering was observed on T2 (75% NPK + 25% FYM) which was 297.75,377.25,430.25 and 340.75 /m2 while minimum tillering was seen in T5 (100% FYM) which was 234.00,307.00,366.08 and 291.25 /m2 respectively. At 30 and 45 DAT, T2(75% NPK + 25% FYM) was statistically at par with T1(100%NPK), T3(50% NPK + 50% FYM) and highly significant with T4(25% NPK + 75% FYM) and T5(100% FYM). Similarly, at 60 and 75DAT, T2 is statistically at par with T1, T3, and T4 but highly significant with T5. This might be due availability of nitrogen at the tillering phase and may be due to increasing organic matter content. A high level of nitrogen plays a vital role in cell division and elongation. (Hasanuzzaman et al., 2010) reported an increase in tiller number per unit area under the combined application of organic and inorganic fertilizer treatment. Organic fertilizer sources offer more balanced nutrition, especially micronutrients which positively affect the number of tillers in rice plants (Belefant-Miller, 2007).

Yield attributing parameters

Net effective tillers

Effective tillers per meter square were significantly influenced by the application of a different combination of organic fertilizer and inorganic fertilizer. A maximum number of effective tillers per meter square were observed on T2 (75%NPK + 25% FYM) which was 315.750 per meter square and was statistically at par with T1, T3, and T4 while, a minimum number of effective tillers per meter square was observed on T5, which was 266.250 per square meter which is highly significant with T2. (Hasanuzzaman et al., 2010) reported an increase in tiller number per unit area under the combined application of organic and inorganic fertilizer treatment. This could have been due to the availability of a high level of nitrogen which plays a vital role in cell division and elongation.

Table 2. Plant height as influenced by the application of different combinations of organic and inorganic fertilizer at Chorkate, Gorkha, 2021

Treatments	Plant height			
	30 DAT	45DAT	60DAT	75DAT
100% NPK	36.48^{ab}	55.10^{ab}	73.11^{b}	93.61^{b}
75%NPK + 25% FYM	37.37^{a}	56.21^{a}	77.07^{a}	95.33 ^{a}
50%NPK + 50% FYM	35.59^{bc}	54.26^{b}	72.40^{b}	92.01 ^{bc}
25%NPK + 75% FYM	34.90^{cd}	53.55^{bc}	73.02^{b}	91.48 ^{c}
100% FYM	33.85^{d}	52.16^{c}	70.01^{c}	88.53 ^{d}
LSD (0.05)	2.93	1.92	2.36	1.59
SEM (+/-)	0.15	0.28	0.34	0.23
F-probability	<0.001	<0.001	<0.001	<0.001
CV%	1.95	2.29	2.1	1.12
Grand Mean	35.63	54.26	73.12	92.19

Table 3. Plant tillers as influenced by the application of different combinations of organic and inorganic fertilizer at Chorkate, Gorkha, 2021

Treatments	Number of tillers			
	30 DAT	45DAT	60DAT	75DAT
100% NPK	263.75^{b}	349.62^{b}	401.50^{b}	313.85^{b}
75%NPK + 25% FYM	297.75^{a}	377.25^{a}	430.25^{a}	340.75^{a}
50%NPK + 50% FYM	260.00^{bc}	334.75^{b}	391.00^{b}	310.25^{b}
25%NPK + 75% FYM	250.75^{c}	323.50^{c}	385.25^{b}	304.50^{b}
100% FYM	234.00^{d}	307.00^{d}	366.08^{c}	291.25^{c}
LSD (0.05)	11.76	15.01	16.76	11.58
SEM (+/-)	1.7	2.17	2.43	1.68
F-probability	<0.01	<0.001	<0.001	<0.001
CV%	2.92	2.88	2.67	2.48
Grand Mean	261.25	338.42	394.4	312.6

Table 4. Numbers of the net effective tiller, filled grains per panicles, sterility % TGW as influenced by the application of different combinations of organic and inorganic fertilizer at Chorkate, Gorkha, 2021

Treatments	Effective tiller per m^2	Filled grain per panicle	Sterility %	TGW	Panicle length (cm)
100% NPK	285.75[b]	130.00[b]	29.38	22.34	23.56[bc]
75%NPK + 25% FYM	315.75[a]	150.25[a]	27.72	22.45	25.06[a]
50%NPK + 50% FYM	285.25[b]	128.75[bc]	29.5	22.34	23.23[b]
25%NPK + 75% FYM	279.75[bc]	120.00[bc]	30.42	22.33	23.36[bc]
100% FYM	266.25[c]	115.25[c]	31.08	22.14	22.77[c]
LSD (0.05)	18.24	13.5	NS	NS	0.75
SEM (+/-)	3.78	1.96	0.57	0.12	0.1
F-Probability	<0.01	<0.01	NS	NS	<0.001
CV%	4.13	6.8	8.73	4.06	2.06
Grand Mean	287.55	148.65	29.625	22.32	23.6

Table 5. Grain yield, Straw yield, and Harvest index as influenced by the application of different organic fertilizers in combination with inorganic fertilizers at Chorkate, Gorkha, 2021

Treatments	Grain yield(ton/ha)	Straw yield (ton/ha)	Harvest index
100% NPK	6.4075[b]	10.435[b]	0.379[bc]
75%NPK + 25% FYM	8.2725[a]	12.146[a]	0.405[a]
50%NPK + 50% FYM	6.1000[b]	9.556[bc]	0.390[ab]
25%NPK + 75% FYM	5.7150[bc]	9.071[c]	0.384[bc]
100% FYM	5.2125[c]	8.868[c]	0.370[c]
LSD(0.05)	1.08	1.3466	0.016
SEM(+/-)	0.11	0.1858	0.002
F-Probability	<0.001	< 0.001	<0.001
CV%	11.08	8.727	2.813
Grand Mean	6.34	11.266	0.386075

Filled grains per panicles and sterility percentage

Filled grains per panicle were significantly influenced by the application of a different combination of organic fertilizer with inorganic fertilizer. A maximum number of filled grains were observed on T2 (75% NPK+ 25% FYM) which was 150.25 per panicle while a minimum number of the filled grains per panicle was observed on T5 (100% FYM) which was 115 filled grains per panicle. The highest number of filled grains per panicle and lowest sterility percentage was found on T2(75%NPK + 25% FYM). This may be due to longer panicle length of T2, slow-release of nitrogen, less volatilization, and leaching loss of nitrogen. In addition, increased organic content increases the carbon content of the soil which might result in high filled grain per panicle and low sterility percentage. (Shenoy and Siddaraju, 2020) noted a significant increase in panicle length due to the application of organic manure and chemical fertilizers. According to Table 4, no significant difference was observed among various treatments regarding the sterility percentage, TGW, and Filled grain per panicle. The numerically highest sterility percentage was found in T5 (31.08%) and the lowest was found on T2 (27.72%).

Thousand-grain weight (TGW)

No significant difference was observed among various treatments regarding the thousand-grain weight. The numerically highest TGW was found in T2 (22.450 gm) and the lowest was found on T5 (22.14 gm).

Panicle length

Panicle length was significantly influenced by the application of organic and inorganic fertilizers. The highest panicle length was found on T2 (75% NPK+ 25% FYM) which was 25.075 cm and it was highly significant with T1, T3, T4, and T5 while the lowest panicle length was found on T5 (100% FYM) which was 22.750 cm.

Grain yield, Straw yield, and Harvest index

Grain yield among various treatments was significantly influenced by the application of organic fertilizer along with inorganic fertilizer. The highest grain yield was found on T2 (75% NPK+ 25% FYM) which was 8.2725 tons/ha followed by T1(100% NPK) which was 6.4075 tons/ha. While lowest yield was found on T5 (100% FYM) which was 5.215 tons/ha. (Table 5)

The straw yield was significantly influenced by the application of organic fertilizer along with inorganic fertilizer. The highest straw yield was found on T2 which was 12.14640 ton/ha which was followed by T1 (10.435 ton/ha) and, the minimum straw yield was found on T5 which was 8.688 ton/ha. (Table 5)

The harvest index was significantly influenced by the application of organic fertilizer along with chemical fertilizer. The highest harvest index was found on T2(75% NPK+ 25% FYM) which was 0.4051 while, the lowest harvest index was found on T5 (100% FYM) which was 0.37042. (Table 5)

The highest straw and grain yield with maximum harvest index was found on T2 (75%NPK + 25% FYM). (Moe et al., 2017) reported that there was a significant variation in the total dry matter accumulation of plants under different levels of inorganic fertilizer. Higher dry matter accumulation was obtained with inorganic fertilizer than organic fertilizer at the vegetative stage, but organic manure combined with inorganic fertilizer treatments produced higher dry matter content compared with organic manure treatments alone. This might have been due to the increased vegetative growth of the plants (Anisuzzaman et al., 2021). It was observed that organic fertilizer alone or combined with chemical fertilizers significantly increased the leaf's length, number, and size as the nutrient

absorption capacity of the plant causes better development of root and carbohydrates translocation from source to growing points caused by the use of organic fertilizer. The increase in plant height, number of tillers per hill, spikelet number per panicle, grain yield, and 1000-grain weight in response to the application of organic and chemical fertilizers is probably due to the enhanced availability of nutrients. The available nutrients might have helped in enhancing the leaf area, which resulted in higher photo-assimilates and more dry matter accumulation (Singh, 2008).

Soil Chemical Properties

After the harvest of rice, laboratory analysis of soil from the experimental plots was done and data were analyzed. Treatments didn't produce significant results for all measured parameters except soil pH and organic matter content but variation was observed. The result showed that the treatment T2 recorded the highest pH, least OM, and highest N content. This might be due to the decrease in soil pH due to the application of chemical fertilizers Highest P_2O_5 and highest K2O were observed in soil from T3 The decrease of soil pH by NPK fertilizer might be explained by leaching of cations, such as potassium, calcium, and magnesium from the soil (Table 6)

According to (Devkota et al., 2019), similar treatments didn't produce significant results for all measured soil parameters but variation was observed.

Cost Analysis

Net return was found highest on T2(75% recommended inorganic fertilizer + 25% recommended organic fertilizer), which was 268390 while the lowest net return was found on T5(100% recommended organic fertilizer) which was NPR 145710. This shows that spring rice cultivation with T2(75% recommended inorganic fertilizer + 25% recommended organic fertilizer) has a relative economic advantage over any other combination of the treatments (Table 7).

Table 6. Soil chemical properties as influenced by the application of different combinations of organic and inorganic fertilizer at Chorkate, Gorkha, 2021

Treatments	Soil pH	Nitrogen %	Phosphorous (kg/ha)	Potassium (kg/ha)	Organic matter %
100% NPK	5.400[b]	0.095	28.56	171.66	1.9625[a]
75%NPK + 25% FYM	5.575[a]	0.0975	20.17	165.06	1.9450[a]
50%NPK + 50% FYM	5.500[ab]	0.0825	29.12	177.3	1.7250[a]
25%NPK + 75% FYM	5.575[a]	0.0875	21.86	174.53	1.7500[a]
100% FYM	5.600[a]	0.07	23.84	173.4	1.2275[b]
LSD(0.05)	0.0236	ns	ns	ns	0.4122
SEM(+/-)	0.002	0.003	12.38	216.11	0.0263
F-Probability	<0.01	NS	NS	NS	<0.01
CV%	1.51	17.753	30.11	18.03	15.5379
Grand Mean	5.53	0.0865	24.712	172.39	1.722

Table 7. Net return incurred after application of different combinations of organic and inorganic fertilizer at Chorkate, Gorkha, 2021

Treatments	Cost of fertilizer	Gross Return	Net Return
T1=100% NPK	10253	230640	220387
T2=75% NPK+ 25% FYM	18940	287330	268390
T3=50% NPK+ 50% FYM	27626	217160	189534
T4=75% NPK+ 25% FYM	36314	203890	167576
T5= 100% FYM	45000	190710	145710

Note: all the amount is in Nepalese Rupees@ cost per ha

Conclusion

The effect of different organic and inorganic fertilizers had a significant effect on the yield of spring rice. It is concluded that the application of different organic and inorganic fertilizers was vital in enhancing the yield of spring rice. 75% recommended inorganic fertilizer + 25% recommended organic fertilizer was superior in terms of plant height, no. of tillers, effective tillers, filled grains per panicle, panicle length, grain yield, straw yield, and harvest index. Overall study shows that application of 75% recommended inorganic fertilizer + 25% recommended organic fertilizer was the best combination as it was superior to other biofertilizer combinations with a net return. So, the spring rice productivity can be enhanced via the adoption of 75% recommended inorganic fertilizer + 25% recommended organic fertilizer in fertilizer management practice at Chorkate, Gorkha.

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