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Effect of Integrated Use of Farmyard Manure and Chemical Fertilizers on Soil Properties and Productivity of Rice in Chitwan

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ABSTRACT

The effect of sole application of farm yard manure (FYM) and combined application of chemical fertilizers and FYM on soil properties and growth and yield traits of rice (Variety: Ramdhan) was studied on sandy loam soil at Rambagh, Chitwan, Nepal from June to November 2019. The seven treatments were studied in a randomized complete block design with four replications: T1: 100% recommended dose of inorganic fertilizer (RDIF) (i.e., 100:60:40 NPK kg ha^{-1}); T2: 50% RDIF+ FYM @ 9.9 Mt ha^{-1}; T3: 50% RDIF+ FYM @ 31.3 Mt ha^{-1}; T4: 50% RDIF+ FYM @ 11.05 Mt ha^{-1}; T5: FYM @ 19.83 Mt ha^{-1}. The results indicated that combined application of chemical fertilizers and farmyard manure was found to have a significant effect on the number of effective tillers per m^{-2} and grain yield of rice. There was no significant interaction between thousand grain weight and sterility percent. The highest grain yield of 3,453.69 kg ha^{-1} and the highest number of effective tillers per m^{-2} (299) were found in the application of 50% RDIF+ FYM @ 31.3 Mt ha^{-1}. The application of the highest level of FYM alone improved the soil properties. The highest values of available soil organic carbon (34.67 Mt ha^{-1}), available soil nitrogen (1.24 Mt ha^{-1}), and available soil phosphorus (39.57 kg ha^{-1}) at a depth of 0–15 cm were found with the application of FYM @ 62.5 Mt ha^{-1}. The findings of this study suggest that farmers can apply FYM @ 62.5 Mt ha^{-1} to improve soil properties and 50% RDIF + FYM @ 31.3 Mt ha^{-1} to have the higher grain yield of rice.

Keywords: Chemical fertilizer, FYM, organic carbon, soil properties, yield

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INTRODUCTION

Farmyard manure (FYM) is an excellent organic source of nutrients that is widely accessible on all farms. Soil structure enhanced by FYM enhances soil structure by increasing soil nitrogen content, nutrient availability, and nutrient mobilization, as well as aeration and water retention (Kumar et al 2019). By improving soil structure, stimulating soil aggregates, boosting cation exchange capacity, and acting as a buffer against pH change in soil, FYM promotes root growth (Olaniyi and Ajibola 2008). FYM is a blended fertilizer that contains all of the major supplements (N, P, K, Ca, Mg, S) as well as micronutrients (Fe, Mn, Cu, Zn) required for plant development (Dejene and Lemlem 2012). As a result, adding farmyard manure into the rice fertilizer schedule and reducing total reliance on chemical fertilizers has a lot of potentials. Organic manure, on the other hand, has a low nutrient content, so a larger amount is needed to provide sufficient nutrients for plant growth (Vanlauwe et al 2010). FYM alone is insufficient as a substitute for inorganic fertilizers to maintain present levels of crop output of high-yielding types (Efthimiadou et al 2010). During the rice plant's mid-tillering stage, however, continuous application of organic fertilizer alone resulted in low yield and low N and K content (Javier et al 2002).

To meet the increasing demand for food of Nepal‘s majority population and to maximize the high yield potential of cereals, higher doses of nutrients in the form of chemical fertilizers are required. Chemical fertilizers are used to address nutrient deficiencies in plants, give high amounts of nourishment to assist plants to tolerate stress, maintain optimum soil fertility, and improve crop quality. Because the nutrients in chemical fertilizers are already water-soluble, they encourage rapid plant development and have a quick and effective effect. Chemical fertilizers contain a high concentration of nutrients; therefore, only a small amount is required for productivity (Han et al 2016). However, there was a long-term loss in soil fertility and productivity in the overall system due to the degeneration of soil health, pollution, and a halt or drop in agricultural production. Chemical fertilizers have been found to increase crop yield for a few years, but they are ineffectual in the long run and promote soil degradation. Chemical fertilizers hasten the decomposition of soil organic matter, causing soil structure to deteriorate and soil aggregation to decrease. As a result, nutrients are easily lost from soils through fixation, leaching, and gas emissions, lowering fertilizer efficiency (Alimi et al 2007). Higher chemical fertilizer doses not only reduce the microbial population (Gruhn et al 2000) but also cause nutrient imbalances in the soil, which can lead to soil acidity and lower crop yields (Ojeniyi 2002).

The effect of organic fertilizer on crop growth as well as the combined use of chemical and organic fertilizer is dependent on application rates and the kind of fertilizer used. Application rates are determined by crop N needs and predicted organic fertilizer N supply rates, but do not take into account the quantity of P and K delivered by organic fertilizers. On the other hand, exorbitant prices, timely unavailability, and the long-term detrimental effects of chemical fertilizers have sparked interest in combining chemical fertilizers and organic manure to sustain rice production (Meena et al 2018). Thus, the quality of FYM and other sources of organic manures, as well as the use of organic fertilizers and the minimal use of chemical fertilizers should be considered, so that sustainability of soil fertility and soil productivity can be maintained while focusing on a sustainable type of agriculture. In Chitwan, the majority of farmers use FYM as an organic manure source (Adhikari 2002). These scenarios necessitate the use of integrated nutrient management in rice production. However, research on integrated nutrient management for rice production is not sufficient in the district, therefore, this study was carried out to study the effect of integrated application of chemical fertilizer and farmyard manure on soil fertility and rice yield in the Chitwan district of Nepal.

MATERIALS AND METHODS

Experimental site

This experiment was carried out in Bharatpur metropolitan city, ward number 5, Rambagh, Chitwan, Bagmati province, Nepal in summer season of 2019. The experimental site falls in the inner Terai region (with 27°41‘N latitude and 84°19‘E longitude) at an elevation of 175 meters above the mean sea level. The experimental plot's soil was slightly acidic and had a sandy loam texture. Soil properties were determined before the start of research by making composite soil samples from soil samples collected from the field at two depths, i.e., 0–15 cm and 15–30 cm. The soil samples were analyzed to determine physico-chemial properties of soil. The physico-chemical properties of the experimental plot before the field experiment have been depicted in Table 1.

Table 1. Physico-chemical properties of experimental plot before field experiment at Bharatpur-5, Rambag, Chitwan, Nepal, 2019

		PH		Organic carbon ($t\ ha^{-1}$)		Nitrogen ($t\ ha^{-1}$)		Phosphorus ($kg\ ha^{-1}$)		Potassium ($kg\ ha^{-1}$)	
Rep	**BD**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**
R1	1.4	6.33	6.31	23.71	14.03	1.86	1.04	96.82	8.11	157.35	70.39
R2	1.3	6.04	5.92	13.92	15.03	1	1.2	8.86	9.37	68.12	66.12
R3	1.4	5.75	5.49	19	21.58	1.66	1.45	14.98	17.62	72.72	97.66
R4	1.4	5.61	5.61	3.92	15.26	1.9	1.27	30.27	27.05	84.60	65.56
Average	**1.38**	**5.93**	**5.83**	**15.14**	**16.47**	**1.60**	**1.24**	**37.73**	**15.53**	**95.70**	**74.93**

Source: Lab analysis report, Rampur

Meteorological information

During the rainy season, the experimental site receives sufficient rainfall, which begins in June and ends in September. The highest rainfall occurs in June and July. Relative humidity begins to rise in May (on average 50%) and reaches a peak (100%) for a few weeks in December and January. Figure 1 shows weekly average data on several weather parameters, such as maximum and minimum temperatures, total rainfall, and relative humidity, observed at the National Maize Research Program (NMRP) during the rice-growing season.

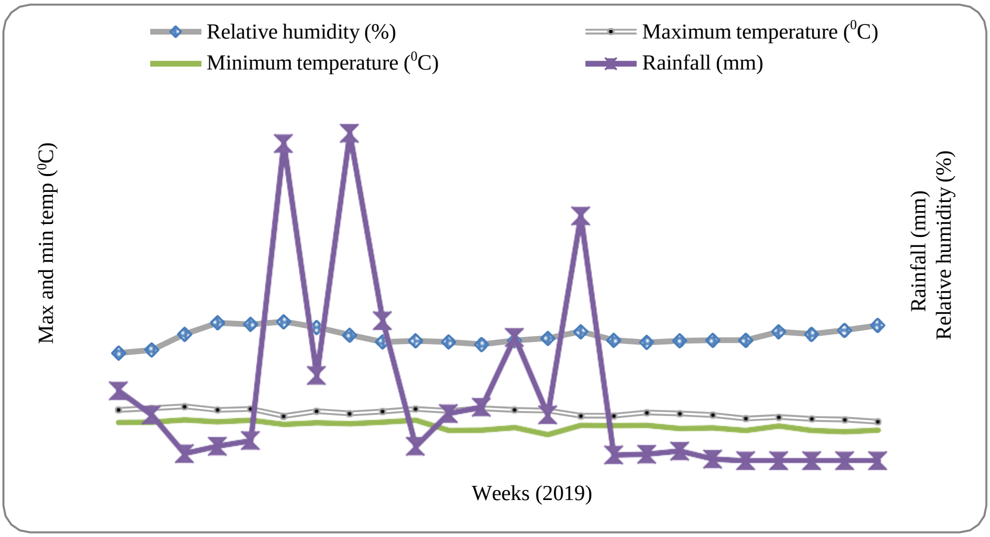

Figure 1. Weather data during the experiment, Rampur, Chitwan

Experimental design and crop management

The experiment used a randomized complete block design (RCBD), with seven treatment combinations and four replications. The details of treatments are described in Table 2. The total area of the experimental plot was 525 m^2 with an individual plot size of 3m × 4m (12 m^2). Rice was sown at a spacing of 20 cm × 20 cm. The variety of rice (*Oryza sativa* L., 2n=2x=24) used in the experiment was Ram Dhan, having the maturity days of 130 to 137 days after sowing and recommended dose of fertilizer as 100:60:40 NPK kg ha^{-1}(MoALD 2019).

The source of nitrogen (N) is urea and di-Ammonium phosphate. The source of phosphorous is di-Ammonium phosphate. Similarly, the source of potassium (K) is murate of potash. The farmyard manure (FYM) used in this experiment was cattle FYM mixed with cattle urine and various types of other organic materials used as bedding under livestock, and remnants of straw and plant stalks fed to animals. The collected FYM was left for five months for complete decomposition and was applied using broadcasting method prior to 15 days of transplanting in the recommended plots. The chemical composition of FYM used in the experiment is given in Table 2.

Table 2. Properties of farm yard manure

S.N.	Parameter	Test method	Observed value	Specification for organic fertilizer
1	Nitrogen% (Oven dry basis),	Kjeldahl Digestion	2.0	1.5
2	Phosphorous as P_2O_5% (Oven dry basis)	Spectrophotometric	0.38	0.75
3	Potassium as K_2O% (Oven dry basis)	AA Spectrometric	0.72	1.5

Table 3. Details of treatments

Treatment	Detail of treatment
T_1	100% RDIF (100:60:40 NPK kg ha^{-1})
T_2	50% RDIF+ FYM @ 9.9 Mt ha^{-1}
T_3	50%RDIF+ FYM @ 31.3 Mt ha^{-1}
T_4	50% RDIF+FYM @ 11.05Mt ha^{-1}
T_5	FYM @ 19.83 Mt ha^{-1}
T_6	FYM @ 62.5 Mt ha^{-1}
T_7	FYM @ 22 Mt ha^{-1}

Furrow irrigation using irrigation pump or channel irrigation was provided up to 5 cm to the experimental field during early tillering stage, panicle initiation stage (6-8 leaf stage), reproductive stage (booting stage) and early grain filling (two weeks after flowering).

Data collection

The total number of tillers per hill from the 5 randomly selected plants was sampled at 30, 60, and 90 DAT to count the total number of tillers m^{-2}. The panicle-bearing tillers were counted from the entire fourth row. The data was taken after the physiological maturity of the crop before the harvest and then converted into effective tillers per square meter. Rice was harvested just after physiological maturity. Threshing was done manually, and the grain was cleaned and sun-dried. Grain and straw yields were recorded after drying. Thousand grain weight, sterility percentage, and grain and straw yield were recorded in grams.

Soil chemical analysis

Following crop harvest, soil samples were obtained at 0–15 cm and 15–30 cm depths from each plot. The collected samples were then properly mixed, dried, and grounded to examine the soil's physicochemical qualities. Table 4 summarizes the procedures used to analyze soil samples.

Table 4. Methods of soil analysis

S.N	Parameter	Analysis method
1	Soil pH	Beckman Glass Electrode pH meter
2	Soil texture	Hydrometer method (Klute 1986)
3	Soil organic matter	Walkley and Black(1934)
4	Soil total nitrogen	Kjeldahl distillation (Bremner and Mulvaney 1982)
5	Soil available phosphorus	Olsen's bicarbonate extraction (Olsen et al1954)
6	Soil available potassium	Ammonium acetate (Knudesen et al 1982).

Statistical analysis

Data were recorded and entered into MS Excel 2016. Data were analyzed using the F-test in R-Studio 1.1.463 with R 3.5.2. Randomized complete block design one-way ANOVA was used to analyze data. Treatment means were compared with Duncan's multiple range tests ($P \leq 0.05$).

RESULTS AND DISCUSSION

Growth and yield traits of rice

The number of effective tillers per square meter was significantly influenced by the application of treatments, and a comparatively higher number (299) of effective tillers was recorded in 50% RDIF+ FYM @ 9.9 Mt ha^{-1}, as compared to other treatments (Table 4). The lowest effective number of tillers was recorded in FYM at 62.5 t ha^{-1} (267.29). The value of a thousand kernels' weight ranged from 20.63 g to 22.06 g depending upon the treatments, and its average value was 21.17 g. Application of chemical fertilizers and improved FYM did not have any significant effect on thousand-grain weight. Although thousand-grain weight was not significantly influenced, a comparatively higher thousand-grain weight (22.06 g) was observed in 19.83 Mt ha^{-1}, whereas the lowest thousand-grain weight (20.63 g) was measured in FYM @ 62.5 Mt ha^{-1} (Table 4). The sterility percentage was not significantly affected by different treatments. However, the lowest sterility percentage (23.45%) was recorded in 50% RDIF+FYM @ 9.9 Mt ha^{-1}, whereas the highest sterility percentage (27.65%) was observed in FYM @ 62.5 Mt ha^{-1} (Table 4).

Application of farmyard manure and chemical fertilizers significantly affected rice straw yield. The application of 50% RDIF+FYM @ 31.3 Mt ha^{-1} produced the highest straw yield (4747.2 kg ha^{-1}), which was superior to treatments like 50% RDIF+FYM @ 11.05 Mt ha^{-1}, FYM @ 19.83 Mt ha^{-1}, FYM @ 62.5 Mt ha^{-1}, and FYM @ 22 Mt ha^{-1}, and statistically similar to 100% RDIF and 50% RDIF+FYM @ 9.9 Mt ha^{-1}. Different integrated nutrient management strategies had a significant effect on rice grain production. The application of 50%RDIF + FYM @ 31.3 Mt ha^{-1} had a higher grain yield (344.69 kg ha^{-1}), which was statistically superior to 50% RDIF + FYM @ 11.05 Mt ha^{-1}, FYM @ 19.83 Mt ha^{-1}, FYM @ 62.5 Mt ha^{-1}, and FYM @ 22 Mt ha^{-1}, and statistically similar to 100% RDIF and 50% RDIF + FYM @ 9.9 Mt ha^{-1}, but FYM @ 19.83 Mt ha^{-1} had the lowest grain yield (2642.55 kg ha^{-1}) (Table 4).

Table 5. Effective tiller, thousand grain weight, sterility percentage, straw and yield of rice under different nutrient management

Treatments	Effective tiller m^{-2}	Thousand grain weight (g)	Sterility percentage	Straw yield, (kg ha^{-1})	Grain yield, (kg ha^{-1})
100% RDIF	292^{a}±1.74	21.50±0.23	25.84±1.19	4389.53^{ab}±6.8	3069.06^{abc}±2.5
50% RDIF+ FYM @ 9.9 Mt ha^{-1}	285^{ab}±2.06	20.93±0.01	23.45±0.53	4389.00^{ab}±7.1	3225.78^{ab}±7.17
50% RDIF+ FYM @ 31.3 Mt ha^{-1}	299^{a}±3.06	21.06±0.03	25.69±0.29	4758.25^{a}±6.6	3453.69^{ab}±4.41
50% RDIF+ FYM @ 11.05 Mt ha^{-1}	259^{abc}±1.16	20.76±0.25	26.95±0.56	3820.28^{cd}±2.0	2814.13^{bc}±2.58
FYM @ 19.83 Mt ha^{-1}	240^{c}±1.24	22.06±0.40	24.95±1.18	3516.60^{de}±12	2642.55^{c}±6.37
FYM @ 62.5 Mt ha^{-1}	267^{abc}±1.72	20.63±0.21	27.65±0.88	4082.78^{bc}±9.2	2903.31^{bc}±3.94
FYM @ 22 Mt ha^{-1}	248^{bc}±2.39	21.23±0.05	24.88±1.11	3144.00^{e}±4.07	2732.53^{c}±3.90
Grand mean	**269.94**	**21.17**	**25.63**	**4014.35**	**2977.29**
P value	0.041	0.527	0.663	0.000	0.005
CV (%)	9.89	4.91	13.13	8.09	8.99
LSD (<0.05)	39.66	1.54	5.00	482.47	398.05

CV: Coefficient of variation, LSD: least significant difference. Means ± standard errors followed by the same letters in the same column are not significantly different at the 0.05 level of probability.

Soil properties after crop harvest

The bulk density was not significantly affected by the tested treatments (Table 6). However, the bulk density of soil was lowest (1.30 g cm^{-3}) in the plot with 50% RDIF + FYM @ 31.3 Mt ha^{-1} and FYM @ 62.5 Mt ha^{-1}. The nutrient management treatments had a significant effect on the pH of the soil. The highest values (6.58) at a depth of 0-15 cm and 6.42 at a depth of 15-30 cm were recorded in FYM @ 22 Mt ha^{-1}, though the pH value was not significant at a depth of 15-30 cm. The maximum pH value was recorded in FYM @ 62.5 Mt ha^{-1}, which was statistically similar to 50% RDIF + FYM @ 11.05 Mt ha^{-1}, FYM @ 19.83 Mt ha^{-1} and FYM @ 22 Mt ha^{-1} at a depth of 0-15cm.There was a significant effect of improved farmyard manure and fertilizers on soil organic carbon at 0–15 cm. At harvest, the highest soil organic carbon (34.68 Mt ha^{-1}) was obtained from the 62.5 Mt/ha FYM but it was similar to the application of (50% RDIF + FYM @ 9.9 Mt ha^{-1}) and (50% RDIF + FYM @ 31.3 Mt ha^{-1}) whereas the lowest soil organic carbon (28.78 Mt ha^{-1}) was found from 100% RDIF. At a depth of 15–30 cm, there was no significant effect of improved farmyard manure or fertilizers on soil organic carbon. However, the highest value of soil organic carbon was found in FYM @ 62.5 Mt ha^{-1} and the lowest (13.225 Mt ha^{-1}) organic carbon was obtained in 100% RDIF (Table 6).

The application of improved FYM and chemical fertilizers affected the available nitrogen content of the soil. The highest content of nitrogen (2464.8 kg ha^{-1}) was found with using improved FYM @ 62.5 Mt ha^{-1} (Table 6). The lowest (1319.98 kg ha^{-1}) content of nitrogen was obtained in the plot receiving 50% RDIF + FYM @ 9.9 Mt $ha^{-1.}$ The application of improved FYM and chemical fertilizers didn‘t have a significant effect on the available phosphorus content of the soil. However, the highest available soil phosphorus (39.57 kg ha^{-1} and 9.54 kg ha^{-1}) at a depth of 0-15 cm and 15-30 cm, respectively, was from the application of FYM @ 62.5 Mt ha^{-1}. The application of FYM @ 22 Mt ha^{-1} resulted in the lowest P concentration (30.57 kg ha^{-1} and 6.16 kg ha^{-1}) at depths of 0-15 cm and 15-30 cm in soil (Table 6).The available potassium in soil was significantly affected by the application of improved farmyard manure and chemical fertilizers in different combinations (Table 6). It was significantly higher (216.01 kg ha^{-1}) in the plot receiving FYM @ 62.5 Mt ha^{-1}, whereas the lowest level of soil potassium, 87.14 kg ha^{-1}, was obtained from the plot receiving 100% RDIF.

Table 6. Effect of different nutrient management on bulk density and soil pH after rice crop harvest

Treatments	**Bulk density (g cm^{-3})**	**pH**	
		0-15 cm	**15-30cm**
100% RDIF	1.35±0.07	6.29^{c}±0.10	6.42±0.08
50% RDIF+ FYM @ 9.9 Mt ha^{-1}	1.37±0.04	6.27^{c}±0.08	6.46±0.06
50% RDIF+ FYM @ 31.3 Mt ha^{-1}	1.30±0.07	6.39^{bc}±0.03	6.4±0.02
50% RDIF+ FYM @ 11.05 Mt ha^{-1}	1.35±0.01	6.55^{ab}±0.04	6.42±0.04
FYM @ 19.83 Mt ha^{-1}	1.42±0.05	6.49^{ab}±0.06	6.45±0.01
FYM @ 62.5 Mt ha^{-1}	1.30±0.08	6.58^{a}±0.05	6.48±0.04
FYM @ 22 Mt ha^{-1}	1.37±0.06	6.52^{ab}±0.04	6.43±0.02
Grand mean	**1.35**	**6.44**	**6.433**
P value	0.286	0.003	0.772
CV (%)	4.53	1.73	1.15
LSD (<0.05)	0.09	0.17	0.11

CV: Coefficient of variation, LSD: least significant difference. Means ± standard errors followed by the same letters in the same column are not significantly different at the 0.05 level of probability.

Table 7. Effect of different nutrient management on soil Organic carbon and Nitrogen after rice crop harvest

Treatments	Organic carbon (Mt ha^{-1})		Nitrogen (Mt ha^{-1})	
	0-15cm	**15-30cm**	**0-15 cm**	**15-30 cm**
100% RDIF	28.77^{b}±0.28	12.32±0.52	0.9±0.29	1.03±0.51
50% RDIF+ FYM @ 9.9 Mt ha^{-1}	32.16^{ab}±0.31	15.22±0.65	0.98±0.25	0.83±0.39
50%RDIF+FYM @ 31.3 Mt ha^{-1}	31.75^{ab}±0.30	14.27±1.15	1.04±0.23	0.95±0.21
50% RDIF+FYM @ 11.05 Mt ha^{-1}	29.76^{b}±0.37	12.77±0.74	1.13±0.18	1.04±0.39
FYM @ 19.83 Mt ha^{-1}	29.94^{b}±0.44	12.97±0.64	0.86±0.17	1.81±0.34
FYM @ 62.5 Mt ha^{-1}	34.67^{a}±0.43	16.09±0.72	1.24±0.16	1.9±0.89
FYM @ 22 Mt ha^{-1}	30.6^{b}±0.57	12.69±0.40	0.9±0.20	1.39±0.65
Grand mean	**31.09**	**13.77**	**1.01**	**1.28**
P value	0.019	0.169	0.952	0.116
CV (%)	6.79	16	24.46	17.42
LSD (<0.05)	3.14	3.27	0.82	0.90

CV: Coefficient of variation, LSD: least significant difference. Means ± standard errors followed by the same letters in the same column are not significantly different at the 0.05 level of probability.

Table 8. Effect of different nutrient management on soil Phosphorus and Potassium after rice crop harvest

Treatments	Phosphorus (kg ha^{-1})		Potassium (kg ha^{-1})	
	0-15cm	**15-30cm**	**0-15 cm**	**15-30cm**
100% RDIF	33.23±0.77	7.75±0.96	87.14^{e}±1.00	81.42±2.01
50% RDIF+ FYM @ 9.9 Mt ha^{-1}	38.62 ±1.08	7.38±5.57	103.79^{cde}±1.48	129.9±3.88
50%RDIF+FYM @ 31.3 Mt ha^{-1}	33.41±3.34	8.97±0.88	136.12^{b}±1.53	78.85±1.38
50% RDIF+FYM @ 11.05 Mt ha^{-1}	33.28±1.38	6.51±0.53	94.811^{de}±1.64	89.22±1.05
FYM @ 19.83 Mt ha^{-1}	37.79±1.02	6.65±0.29	119.63^{bcd}±1.53	120.7±1.17
FYM @ 62.5 Mt ha^{-1}	39.57±1.06	9.54±0.36	216.012^{a}±0.73	116.6±2.72
FYM @ 22 Mt ha^{-1}	30.57±1.65	6.16±0.24	122.25^{bc}±3.2	249.61±21.5
Grand mean	**35.21**	**7.56**	**125.68**	**123.76**
P value	0.744	0.384	0.000	0.546
CV (%)	25.50	31.83	13.43	10.38
LSD (<0.05)	13.34	3.58	25.0838	190.07

CV: Coefficient of variation, LSD: least significant difference. Means ± standard errors followed by the same letters in the same column are not significantly different at the 0.05 level of probability.

Application of 50% RDIF + FYM @ 31.3 Mt ha^{-1}had the highest number of effective tillers in this study, which was statistically similar to 100% RDIF (i.e., 100:60:40 NPK kg ha^{-1}), 50% RDIF + FYM @ 9.9 Mt ha^{-1}, 50% RDIF + FYM @ 11.05 Mt ha^{-1}, and FYM @ 62.5 Mt ha^{-1} (Table 5). The number of effective tillers, rather than the overall number of tillers, determines the yield of a rice plant. From this, we can conclude that using more chemical fertilizer to produce effective tillers is unnecessary if we can supplement with organic manures that also provide essential micronutrients to the plants and this finding is supported by Rakshit et al (2008). The yield of grain and straw was also higher in 50% RDIF + FYM @ 31.3 Mt ha^{-1} (Table 4). Ebaid et al (2007) concluded that the rise in grain and straw yield could be due to the rise in yield parameters (plant height, leaf area index, number of tillers, and number of effective tillers per square meter). The research conducted by Ebaid et al (2007) stated that the increased nutrient availability increased the absorption of nitrogen and other macro-and microelements, as well as the generation and translocation of dry matter from source to sink, resulting in higher straw and grain yields Another reason could be improved N utilization efficiency as a result of integrated application of organic and inorganic fertilizers, which has led to increased yield due to increased organic carbon accumulation (Pan et al 2009), as well as increased nutrient availability and soil environment modification for better nutrient and water retention during critical crop growth stages (Dass et al 2009).

Bulk density was not significantly affected by the integrated use of improved FYM and chemical fertilizers. However, the bulk density of soil was the lowest in plots receiving treatment of 50% RDIF + FYM @ 31.3 Mt ha^{-1} (Table 6). Increased soil bio pores, aeration, higher soil organic carbon content, and better soil aggregation due to the application of bulky organic manure (Gangwar et al 2006), and polysaccharides, cellulose, and humus released during the decomposition of organic manure are responsible for firm binding among soil particles in more stable aggregates, causing bulk density reduction (Pareek and Yadav 2011). Kumar et al (1992) found that using FYM did not change the bulk density of the soil, but it did increase the size of the water-stable aggregates by more than 2.0 mm. Meena et al (2018) also found that applying FYM alone or in combination with NPK resulted in lower bulk density than chemical fertilizer and control treatments, respectively. In comparison to 100 percent NPK and 150 % NPK using chemical fertilizer without organics, Bandyopadhyay et al (2010) and Katkar et al (2012) found that applying farmyard manure at the rate of 10 Mt ha^{-1} resulted in a considerable drop in bulk density. The integrated use of improved FYM and chemical fertilizer had a significant effect on the pH of the soil. The maximum pH value was recorded in FYM @ 62.5 Mt ha^{-1}, which was statistically similar to 50% RDIF+FYM @ 11.05 Mt ha^{-1}, FYM @ 19.83 Mt ha^{-1}, and FYM @ 22 Mt ha^{-1} (Table 6). The complexing of exchangeable and free Al^{+3} ions by aliphatic and aromatic hydroxyl acids, humus, and lignin produced during the degradation of organic materials could be linked to the increase in soil pH caused by FYM treatment (Grewal et al 1971).

There was a significant effect of improved farmyard manure and fertilizers on soil organic carbon. In the current investigation, the application of FYM @ 62.5 Mt ha^{-1} significantly increased soil organic carbon, which was statistically similar to the application of 50% RDIF + FYM @ 9.9 Mt ha^{-1} and 50% RDIF + FYM @ 31.3 Mt ha^{-1} (Table 7). In all treatments except the sole inorganic treatment, the organic carbon status of the soil improved compared to the starting value and this results is in accordance to the findings of Gogoi et al (2015). The carbonaceous nature of organic manures, as well as an increase in microbial activity in the soil, were both responsible for the rise in organic carbon with the addition of organic manures. Application of FYM @ 62.5 Mt ha^{-1} resulted in the highest soil N, though the result was not significant (Table 7). This could be because the higher amount of nitrogen applied through organic sources decomposes quickly, producing more organic acid and thus increasing nitrogen availability; it could also be because the microbial population and their decomposition activities have increased, allowing organically bound nitrogen to be converted to inorganic form without harming the soil (Singh and Bohra 2014). Gupta (2000) found that the available N, P, and K status in soil increased with the individual application of fertilizer nutrients, but the available N, P, and K build-up remained greater in FYM/compost treated plots. Similarly, Aziz et al (2010) also found higher soil N content after a maize harvest for FYM application. Available soil phosphorus content did not vary significantly with the application of improved farmyard manure and chemical fertilizer. The highest available soil phosphorus was observed from the application of FYM at 62.5 Mt ha^{-1} (Table 8). The increase in available phosphorus could be attributed to the addition of P through FYM and the reduction of soil P fixation by organic anions formed during FYM decomposition (Ali et al 2009). Organic anions formed during the breakdown of OM form stable complexes with Fe^{3+} and Al^{3+}, preventing their interaction with phosphate ions, resulting in significantly increased available P due to the organic source. Aziz et al (2010) measured maximum soil P concentration after a maize harvest for FYM application. The available potassium in soil was significantly affected by the application of farmyard manure and chemical fertilizers in different combinations, and the highest available potassium was found from the application of FYM @ 62.5 Mt ha^{-1}, which was significantly superior to other treatments (Table 8). According to Aziz et al (2010), manure treatment raises soil K content substantially. Halvin et al (1990) reported that when more organic matter is present in the soil as a result of organic fertilization, the soil‘s physical and chemical properties, such as aggregate stability and nutrient availability, are influenced quickly.

CONCLUSIONS

The effect of farmyard manure and fertilizer was significant on effective tillers m^{-2}, grain yield and straw yield. The values of yield and attributes were found to be higher with the application of 50% RDIF+ FYM @ 31.3 Mt ha^{-1} however these agronomic traits did not significantly differ with the application of 50% RDIF+FYM @ 11.05 Mt ha^{-1} . Hence, rice crops can be grown successfully by using application of 50% RDIF plusFYM @ 11.05 Mt ha^{-1}. In order to completely comprehend the benefits of combination of organic manure and chemical fertilizer in various soil types and climatic conditions, multi-year research are required. Even though, the findings of this one season research also illustrates the potential contribution on the combination of organic and inorganic fertilizer.

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AUTHORS' CONTRIBUTION

Sarita Lamichhane, Babu Ram Khanal, Ajay Jaishi, Sandesh Bhatta, Roshana Gautam designed and conceived the experiments carried out the experiments and analyzed the results and interpreted the data and wrote the paper. Jiban Shrestha analyzed data and finalized the paper.

CONFLICTS OF INTEREST

The authors declare no any conflict of interest to disclose.

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