American Journal of Agriculture and Forestry
2015; 3(3): 120-123
Published online May 25, 2015 (http://www.sciencepublishinggroup.com/j/ajaf)
doi: 10.11648/j.ajaf.20150303.20
ISSN: 2330-8583 (Print); ISSN: 2330-8591 (Online)

Soil Fertility Status of Rice Field in Paundi Watershed, Lamjung District, Nepal

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To cite this article:
Ram Kumar Shrestha. Soil Fertility Status of Rice Field in Paundi Watershed, Lamjung District, Nepal. *American Journal of Agriculture and Forestry*. Vol. 3, No. 3, 2015, pp. 120-123. doi: 10.11648/j.ajaf.20150303.20

Abstract: From May to November 2014, a research was carried out to study the soil fertility status of lowland paddy field differed in the cropping system in Paundi watershed, Nepal. A total of 20 soil samples were collected and analyzed, and a household survey was carried out to collect the information regarding soil fertility management practices being adopted along with crops yield. Average annual inputs of the organic manure, urea, Diammonium phosphate (DAP) and Muriate of potash (MoP) were 21 t ha^{-1}, 143 kg ha^{-1}, 116 kg ha^{-1} and 16 kg ha^{-1} respectively. Maize field received significantly higher amount of the organic manure, whereas the rice crop received the higher amount of the urea and DAP. Terrace riser slicing and the legume integrations were the other soil fertility management strategies being adopted by farmers. Soils were silt clay loam and were acidic. The soil organic matter in paddy field was low though the level was significantly higher in rice-rice cropping system than that of in rice-maize system. Most of the soils were low in the soil total nitrogen and available phosphorus. Potassium appeared to be low in the study area. Available zinc was found to be adequate in both types of the paddy field. The yield of the wet season rice, dry season rice and maize crop were 3.75, 2.0 and 2.6 t ha^{-1} respectively. Appropriate soil fertility management practices should be adopted to improve the soil fertility level in the study area.

Keywords: Cropping System, Paddy Field, Paundi Watershed, Soil Fertility

1. Introduction

Rice-based cropping systems are prevalent in lowland terai and the foot hills of Nepal covering about 765,000 hectares [1]. The agricultural environment of the mid-hills of Nepal is degrading at a high rate [2] & the issues are becoming critical for the productivity of midhills. Nepalese Soils across the country are low in organic matter (OM), mostly acidic in reaction, deficient in nitrogen (N) and phosphorus (P); exchangeable potassium (K), zinc (Zn), boron (B), cupper (Cu), manganese (Mn) and molybdenum [3][4][5][6]. Negative nutrient balances have resulted significant depletion of soil nutrients in irrigated rice areas of tropical Asia [7]. This problem is severe in the hilly regions due to the loss of the soil and soil nutrients by soil erosion. As high as ten tons of the soils per hectare are annually lost even from the well-managed paddy terraces [8] causing soil fertility degradation. These all have been threatening the sustainability of agriculture [9]. Soil fertility status is highly determined by both natural factors such as parent materials, climate, and soil age as well as the socioeconomic conditions such as inputs of manure and fertilizers [10, 11] which are highly specific to the local conditions. Limited studied have been carried out to assess the soil fertility status in different part of the country and study specific to this location too is yet to be done. Assessment of soil fertility status provides a basis not only for evaluating the effectiveness and efficiency of the existing soil fertility management strategies but also provides the basis for site specific fertilizer recommendation for the optimum crop yield. The main objective of this study was to evaluate the soil fertility status in relation with soil fertility management practices and crops yield of the low land paddy field in Paundi Watershed.

2. Material and Methods

This study was carried out at paddy production sites in Paundi Watershed (Lamjung and Tanahun district), Nepal from May to November, 2014. A total of twenty farm households (HHs)-10 each for rice-rice system and rice-maize system- were purposively selected. A household survey using pretested semi-structured interview schedule was conducted to assess the soil fertility management practices and crop yield. A total of twenty composite samples were collected from 0-20 cm soil depth at the vegetative growth stage (15-20 days after transplanting) during July 2014 and analyzed for important physical and chemical properties that influences soil fertility in the Soil Science Laboratory of Soil Management Directorate, Hariharbhawan, Lalitpur by using standard methods as described in table 1.

For the interpretation of the soil test value for different soil chemical parameters, this study used the ranking system as described by Pradhan [12]. Data collected from the field survey and from soil analysis were entered into SPSS Window version 17.0. Treatment mean separation were done using Tukey Test and figures were created using MS Excel 2008.

Table 1. *Methods of the soil analysis.*

Soil Characteristics	Standard Method
Soil Texture	Hydrometer method
Soil pH	Electronic pH meter (1:1 soil water suspension method)
Soil organic matter (%)	Wakley-Black method
Soil Total Nitrogen (%)	Microjeldahl method
Soil available Phosphorus (kg ha^{-1})	Modified Olsen's bicarbonate method
Soil available Potassium (kg ha^{-1})	Neutral normal ammonium acetate extraction by flame photometer Method
Soil available Zinc (kg ha^{-1})	DTPA extraction by Atomic Absorption Spectrometer

3. Results and Discussion

3.1. Soil Fertility Management Practices

Result shows that farmers were using mainly FYM as the sources of organic manure- other major sources being goat manure and poultry manure. Organic manures were applied mainly for the maize and dry season rice (Table 2). Rice-maize system received significantly higher amount of the organic manure annually (31 t ha^{-1}) than that of the rice-rice system (12 t ha^{-1}).

Table 2. *Inputs of organic and inorganic sources (mean±SE) of the plant nutrients in rice-based system.*

Manure/Fertilizer	Rice-Rice system		Rice-Maize system	
	Dry season rice	Wet season rice	Maize	Rice
FYM t ha^{-1}	6.6±2.27	1.86±0.3	19.4±0.83	2.58±1.72
Poultry manure t ha^{-1}	0.81±0.61	0.83±0.61	2.67±1.29	3.28±1.37
Goat manure t ha^{-1}	0.95±0.53	0.48±0.32	1.18±0.89	1.71±0.89
Urea (kg ha^{-1})	80.13±7.37	82.0±2.0	42.3±6.75	81.6±3.38
DAP (kg ha^{-1})	86.96±17.49	88.5±10.85	7.5±6.02	49.2±6.71
MOP (kg ha^{-1})	5.0±3.41	9.0±6.40	5.0±3.41	12.2±4.15

Applications of the urea and diammonium phosphate (DAP) were the customary practices for the crop production. Amount of their application, however, varied with the crop and cropping system. Rice crop- irrespective of the season- received significantly higher amount of urea (>80 kg ha^{-1}). Farmer's applied >80 Kg DAP per hectare when double rice system was being adopted. Rice-Maize cropping system received significantly lower amount of DAP. Few farmers had been applying muriate of potash (MOP). None of the farmers were using micronutrient in both types of cropping systems. Almost all the farmers were adopting the practices of terrace riser slicing and legume crop inclusion as a soil fertility management strategy in rice field- bean and soybean being the dominant leguminous crops intercropped in maize and wet season rice field respectively.

It was observed that soil testing based fertilizer application was almost zero in the study site. Application of twenty tons per hectare of the FYM for maize production was very high than the recommended dose of 6 ton ha^{-1} [13]. Similar kind of the practice has been observed by Regmi and Zoebisch [14].

3.2. Soil Fertility Status

3.2.1. Soil Texture, Soil pH, Organic Matter and Nitrogen

The area was mainly dominated with silt loam and silty clay loam soil. The result shows that the soils were mostly acidic in reaction in rice-rice field (pH 5.28) and was slightly acidic in rice-maize field (pH 6.11). On average, the medium level of the soil OM content in the rice-rice cropping system

(2.27%) did not significantly differed with that of the rice-maize cropping system (2.08%). Sixty percent of the soil samples from rice-rice system showed low level of OM and this reached to 80% for that of the rice-maize cropping system. Paddy field with both types of the cropping systems showed low level of total N (<0.1%). However, the rice-maize system showed significantly higher level of total N than rice-rice system (Table 3). About 80% soils were low in N in rice-rice system and this figure was 60% for rice-maize system.

The soil acidity is the basic characteristics of the soil in mid hills of Nepal. Acid parent materials and the unbalance use of the chemical fertilizers as well as depletion of the soil OM are reported to be the major causes of the soil acidity throughout the country [5]. Relatively higher amount of the OM in the rice-rice system may be due to flooding of the field for longer duration than that of the rice-maize system. Low level of the soil total N in the study area seems due to the low level of the N application (Table 2). This may be also attributed to the higher N loss from the double rice system.

3.2.2. Available Phosphorus and Potassium

Rice-rice system, on average, contained low level of the available P (28 kg ha^{-1}) which was significantly lower than medium level of P (64 kg ha^{-1}) in the rice-maize system. It was found that 60% of the soils in rice-rice system were low in available P (<31 kg ha^{-1}). Higher P in rice-maize system can be attributed to the higher amount of the organic manures addition. Though rice-rice system often received higher amount of the DAP, the added P might be immobilized as phosphate of aluminum or iron in acidic soil.

Though, soils of both types of the cropping systems were low in available K (<110 kg ha^{-1}), this was significantly higher for rice-maize system (<84 kg ha^{-1}) than that of the rice-rice system (64 kg ha^{-1}). Unbalanced use of the fertilizers-excluding K fertilizers- might be the causes of the depletion of the available K in the soil.

3.2.3. Available Zinc

The result showed that the supply of the Zn is not limiting in both types of cropping systems (>0.5 mg Kg^{-1} soil) and the concentration is significantly higher in rice-maize system (1.05 mg Kg^{-1} soil) than rice-rice system (0.77 mg Kg^{-1} soil) (Table 3). Though the farmers were not applying Zn fertilizer to the field, under the prolong flooding conditions, higher level of the carbonates might be responsible for the Zn immobilization in rice field [7].

3.3. Crop Yield

Irrespective of the cropping system, the average yield of the wet season rice did not differ. The yield of the wet season rice, however, was significantly higher than that of the dry season rice (Fig 1). The yield of the dry season rice was found as 2.3 t ha^{-1}. And the average maize yield was found to be 2.6 t ha^{-1}.

The yield of the wet season rice appeared to be above the national average yield of 3.21 t ha^{-1} in 2012/013. However, the yield of the maize was lower as compared to the national average yield of 4.44 t ha^{-1} for the same year [15]. Such higher yield in spite of the lower fertility status suggests that factors other than the plant nutrients- such as use of hybrid varieties- under the study highly influence the crop yield.

4. Conclusion

Soil fertility level is affected by both natural factors and management practices, and its assessment is needed to develop appropriate fertility management strategies for better crop production. From the above mentioned results, it can be concluded that paddy fields in the study area- affected by cropping system- vary in terms of the different soil fertility parameters, and are low in OM, total N, available P, available K, and available Zn. Reduced use of the organic manures and increasing dependency on the chemical fertilizers may further decrease the availability of various plant nutrients and eventually the crop yield. Integrated approach of the plant nutrient management that relies on the nutrient balance is needed to maintain the optimum level of plant nutrients for the production of crops in sustainable manner.

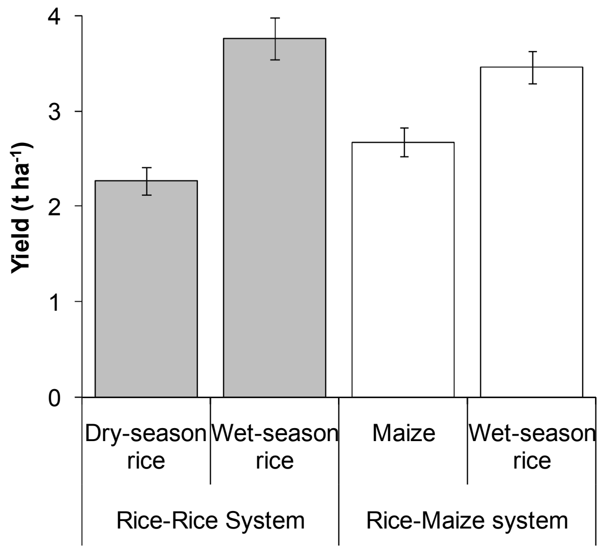

Figure 1. *Yield of the crops under different cropping system in the paddy field.*

Acknowledgements

Funding from the University Grant Commissions, Tribhuvan University, Nepal to conduct this study is highly acknowledged. The author is especially thankful to the farmers in the study area, who helped to explore the information required for this study.

Table 3. *Analysis of soil samples from Paundi Watershed (0-20 cm depth).*

Soil Sample I. D.	Soil pH	OM (%)	Total N (%)	Available P (Kg ha^{-1})	Available K (Kg ha^{-1})	Available Zn (Kg ha^{-1})
Rice-Rice System						
1.	4.90	2.0	0.06	17.0	75.0	0.65
2.	5.20	2.3	0.07	26.0	50.0	0.77
3.	4.80	1.9	0.07	21.0	40.0	0.56
4.	5.20	2.5	0.11	41.0	90.0	0.71
5.	5.40	2.3	0.06	32.0	75.0	0.96
6.	5.20	2.6	0.04	31.0	99.0	1.04
7.	5.54	1.8	0.11	22.0	46.0	0.77
8.	5.30	2.2	0.06	19.0	57.0	0.64
9.	5.10	2.6	0.07	30.0	47.0	0.58
10.	6.20	2.5	0.05	41.0	69.0	1.06
Mean	5.28	2.3	0.07	28.0	64.8	0.77
Standard Deviation	0.39	0.3	0.02	8.6	20.0	0.19
Rice-Maize System						
11.	5.65	2.1	0.08	67.0	86.0	0.94
12.	6.32	2.4	0.05	76.0	86.0	0.99
13.	6.50	2.2	0.16	34.0	97.0	1.27
14.	6.49	2.7	0.15	84.0	105.0	0.87
15.	6.55	2.0	0.07	35.0	78.0	1.09
16.	6.47	2.4	0.07	42.0	94.0	1.26
17.	5.37	1.7	0.13	101.0	106.0	0.94
18.	6.16	2.6	0.06	51.0	99.0	1.33
19.	5.43	2.2	0.09	64.0	47.0	0.75
20.	6.19	2.0	0.12	90.0	48.0	1.01
Mean	6.11	2.2	0.09	64.4	84.6	1.05
Standard Deviation	0.46	0.3	0.04	23.5	21.4	0.19

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