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RICE STRAW MANAGEMENT PRACTICES IN RUPANDEHI DISTRICT, NEPAL

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ABSTRACT

Rice straw management has been a serious issue after the increasing use of combine harvesters to harvest rice in southern plains of Nepal since these machines cuts rice 15-20 cm above the ground and leaves huge amount of residues in the field. A face-to-face semi-structured questionnaire survey was carried out in 60 households of straw burning, and 60 households of straw incorporation to find out straw management practices adopted by farmers, their motive behind choosing those practices and timing of carrying out those practices. Farmers practicing those straw management practices for at least five years was considered as final respondent. Respondents were selected by using purposive sampling technique. Survey was carried out in six places of Rupandehi district where the problem of rice residue burning is severe mainly due to the use of combine harvesters in rice and wheat. Study resulted soil fertility enhancement as the primary reason behind both straw burning practice as well as straw incorporation practice adopted by farmers. Timing of rice straw burning was within 1 week of harvesting rice by majority of farmers. Timing of soil incorporation of rice straw followed by majority of farmers was 8-12 days after harvesting rice. Straw burning results the nutrients imbalance and creates environmental pollution. So, soil incorporation of rice straw is suggested to return nutrients back to the soil.

Keywords: Management, rice-wheat, soil fertility, straw.

INTRODUCTION

Rice-wheat (RW) sequences comprise important food production systems in Nepal. In South Asia, the RW production systems occupy about 13.5 million ha (10 million in India, 2.2 million in Pakistan, 0.8 million in Bangladesh and 0.5 million in Nepal) (Ladha *et al*., 2000). This cropping system has maintained the balance between food supply and population growth but recent evidence shows that productivity and sustainability of this system is threatened as yields of both rice and wheat are either stagnant or decreasing and total factor productivity is declining (USAID, 2009). The dominant characteristic of the system is the repeated transition from the anaerobic conditions for rice to aerobic conditions for wheat. This has great impact on the soil physical properties, as well as on the chemical reactions of indigenous and exogenous nutrients in the soil (Timsina and Connor, 2001). A rice-wheat sequence that yields 7 t ha^{-1} of rice and 4 t ha^{-1} of wheat removes more than 300 kg of nitrogen (N), 30 kg of phosphorus (P) and 300 kg of potassium (K) per hectare from the soil (Singh & Singh, 2001). Another study estimates that a 10 t ha^{-1} crop yield removes 730 kg NPK from the soil (Gupta *et al*., 2007).

Nepal produces 19.41 million metric tons of agricultural residues annually (WECS, 2010). The major sources of residues are rice, maize, wheat, sugarcane, grain legumes, and millets. Just three crops namely the rice, wheat and maize provide more than three-fourth of the total residue production. The largest amount of residue is produced from rice accounting 47.3% of the total followed by maize (24.6%). About six percent of the crop residues in the country are used as fuels generating 14.6 million Gigajoule (GJ) of energy. Out of the energy from the agricultural residues, 90.8% is used for residential purposes and rest in industrial uses (WECS, 2010). Though quite a large amount of energy comes from controlled burning of agricultural residues, large parts of them, particularly those of rice, maize, wheat and sugarcane are burnt in open field. Recent introduction of combine harvesters in southern plain areas of the country for rice and wheat harvesting has aggravated the problem of straw burning (Pant, 2013).

Beres and Kanzinci (2000) reported that recycling of crop residues could be one of the ways of improving soil nutrient content and maintaining soil productivity. Also, they can reduce fertilizers usage in soil. Crop residues provide the substrate, and carbon and nitrogen for the activity of soil microorganisms in formation of soil organic matter (SOM). But those organisms also compete with plants for available nutrients, including those released from residues by decomposition. The effects are most pronounced when residues are incorporated into the soil (Ponnamperuma, 1984; Ladha *et al*., 2000).The nutrient content of residues, the rapid release of some nutrients, their immobilization by the soil microflora, and subsequent release in available form or fixation in resistant SOM, guide the principles of residue management in crop nutrition. About 25 % of N and P, 50 % of sulphur (S) and 75 % of K uptake by cereal crops are retained in crop residues, making them viable nutrient sources (Gadde *et al*., 2009a; Gadde *et al.,* 2009b).

Straw is also an important source of micronutrients such as zinc (Zn) and the most important influence on the cumulative silicon (Si) balance in rice (Dobermann & Fairhurst, 2002). Straw is the only organic material available in significant quantities to most rice farmers. About 40% of the N, 30 to 35% of the P, 80 to 85% of the K, and 40 to 50% of the S taken up by rice remains in vegetative plant parts at crop maturity (Dobermann & Fairhurst, 2002). Straw is removed from the field, burned in situ, piled or spread in the field, incorporated in the soil, or used as mulch for the following crop. Each of these measures has a different effect on overall nutrient balance and long-term soil fertility.

Terai (southern plain) region is rich in crop productivity and regarded as the basket of food grain in Nepal producing large amount of rice and its residues. About 60% of the total residue production in the country comes from Terai alone followed by hill (35%), and contribution of Mountain region is very low (5%), and rice is the largest (58%) source of residue in Terai (WECS, 2010). Majority of the farmers in Terai area used to burn agricultural residue for a long time. The rice straw burning in Terai is particularly challenging in terms of volume of the straw burnt and it is increasing in the areas where the combine harvester is increasingly being used for harvesting rice (Timsina & Connor, 2001).

The recycling of its residues has the great potential to return a considerable amount of plant nutrients to the soil in the rice-wheat cropping systems. The yield stagnation consequent upon the declining soil organic carbon is a major threat to this system. Therefore, it is a great challenge to the agriculturists to manage rice residues effectively and efficiently for enhancing sequestration of carbon and maintaining the sustainability of production. Hence, a survey was done to find out rice straw management practices adopted by farmers in rice-wheat systems in Rupandehi district, the motive behind straw burning and straw incorporation practices and the timing of those management options.

MATERIALS AND METHODS

Description of study area

The study was carried out in Rupandehi district located in the Lumbini province of Southern Nepal (Figure 1). The district has the longitude of 83°26’59.99” E and latitude of 27°29’59.99” N covering an area of 1360 km^2.

Figure 1. Map of Nepal showing Rupandehi district

Survey design

Survey was carried out in Rupandehi district where the problem of rice residue burning is severe mainly due to the use of combine harvesters in rice and wheat. Six places of Rupandehi district were selected by using purposive sampling technique which involves Tillotama-13, Shivpur, Aamua, Pharsatikar, Sainamaina, and Devdaha. The study was mainly based on the primary data obtained from the respondents (rice-wheat producers). For interviewing respondents, a semi-structured questionnaire was designed and pre-tested among 5% of respondents who were not the part of the actual survey.

Questionnaire survey was carried out in 60 households of straw burning and 60 households of straw incorporation. Farmers carrying out those practices for at least five years was considered as final respondent. Questionnaire survey was carried out in 20 households of each place Altogether there were 120 respondent farmers included in the questionnaire survey. Survey was carried out through checklist survey, key informants interview, focus group discussion and direct observation in the field.

Statistical analysis and data presentation

The data collected through personal interview were coded and tabulated for computer entry. The data were mainly subjected to descriptive and analytical analysis. A Chi-square test χ^2 ($p<0.005$) used to investigate if there was a link between socio-demographic characteristics, farming system and rice straw management practices. Data entry, and processing and analysis were done using Microsoft Office Excel 2019 (Microsoft Corp., Redmond, WA, USA). Further analysis was done using SPSS ver. 21 (IBM Corp., Armonk, NY, USA).

RESULTS AND DISCUSSION

Reasons for rice straw burning

There was no significant role of gender in reasons for burning ($\chi^2=4.243$, $p>0.05$). It was found that 50% of the female headed households and 46.3% of the male headed households stated soil fertility enhancement as the reason for rice straw burning [Figure 2(a)]. However, constraints that led farmers to burn rice straw according to ICIMOD (2020) are tight harvesting and sowing schedule, labour shortage, and burning being the most economical way to address rice straw.

Few merits of residue burning are demonstrated such as reduction in pest, disease and weed infestation However, most of the researches and experiments studied till now have shown that rice straw burning does not contribute to the soil fertility improvement. Rather burning has shown to degrade the soil fertility status by killing the beneficial microorganisms. According to Ademe (2015), Continuous burning of crop residues can lead to soil fertility losses, soil structure breakdown, and increased soil erosion. Cereal straw burning also decreases the soil microbial population. Furthermore, repeated burnings could permanently decrease the bacterial population in the top 2.5 cm of soil (Bhuvaneshwari *et al.*2019)

Farmers practicing rainfed and irrigated farming system differed significantly in selecting the reason for burning ($\chi^2=10.503$, $p<0.05$). It was found that 41.7% of the rainfed farming system and 53.3% of the irrigated farming system stated soil fertility enhancement as the reason for rice straw burning [Figure 2(b)] ().

This result contradicts with the result of Bijay-singh *et.al.* (2002) which states the primary reason behind straw burning in South Asia was to minimize possible yield loss in subsequent crop due to poor plant establishment and insects, pests, and diseases. Ghimire (2007) had shown how some of the carbons contained in the crop residue is lost if it is burnt in the field. Studies suggest that crop residue burning contribute to SOC loss (Lal *et al*., 2007; Ghimire *et al*., 2012; Ghimire *et al*., 2015)

Time for rice straw burning

There was no significant difference in timing of burning with respect to gender ($\chi^2=1.202$, $p>0.05$). It was found that 50% of the male headed households and 55.3% of the female headed households burned rice straw within one week of harvesting [Figure 3 (a)]. There was significant difference in timing of burning by respondents possessing rainfed or irrigated land ($\chi^2=12.902$, $p<0.01$).

It was found that 48.3% of the farmers in rainfed farming system and 55% of the farmers in irrigated farming system burned the rice straw within one week of harvesting [Figure 3 (b)]. This result is supported by the study of Lin and Begho (2022) which showed that due to the short gap between harvesting and sowing of wheat crop as well as mechanization of harvesting which leaves huge amount of residues in the field, farmers' burnt rice straw residues within one week of harvesting rice. This result is also supported by ICIMOD (2020) stating that tight harvesting and sowing schedule, labour shortage, and crop residue unaddressed by combine harvesters led to the burning of rice straw within a week of harvesting rice.

Reasons for soil incorporation of rice straw

There was no significant difference in selecting the reasons for soil incorporation with respect to gender (χ^2=5.95, p>0.05). It was found that 41.5% of the female headed households and 60.5% of the male headed households stated soil fertility enhancement as the reason for soil incorporation of rice straw [Figure 4 (a)].

Farmers practicing rainfed and irrigated farming system did not differ significantly in selecting the reason for soil incorporation of straw (χ^2=4.61, p>0.05). It was found that 43.3% of the rainfed farming system and 51.7% of the irrigated farming system stated soil fertility enhancement as the reason for soil incorporation of rice straw [Figure 4(b)].

This result aligns with the study by Nawaz *et al.*(2020) which illustrates residue incorporation strengthens soil nutrient recycling and improves soil health by increasing soil organic matter. Additionally, Kumar *et al.,* (2005) published the findings which showed that rice residue incorporation enhances grain yield and net returns of the subsequent wheat crop. The benefits of sequestering SOC by adding crop residues have been well documented in the temperate regions (Aulakh et al., 2001).

Time for soil incorporation of rice straw

There is no significant difference in timing of rice straw incorporation with respect to gender (χ^2=1.698, p>0.05). It was found that 62.2% of the male headed households and 55.3% of the female headed households incorporated rice straw within 8-12 days of harvesting (Figure 5).

However, various researches advocate to incorporate rice straw about 15-20 days before wheat seeding to increase crop productivity and improve soil health (Bijay-Singh et al., 2008), but demands optimized fertilizer-N management in view of temporary lock-up of applied N (Singh et al., 2005).

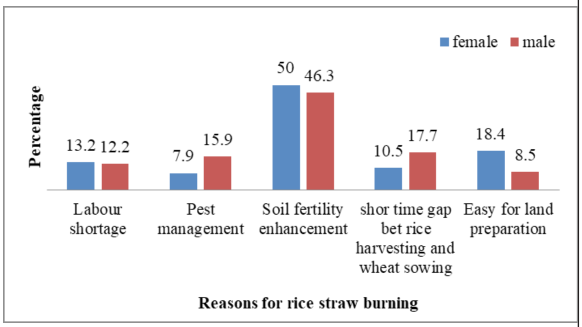

Figure 2 (a). Reasons for rice straw burning with respect to gender in Rupandehi, Nepal

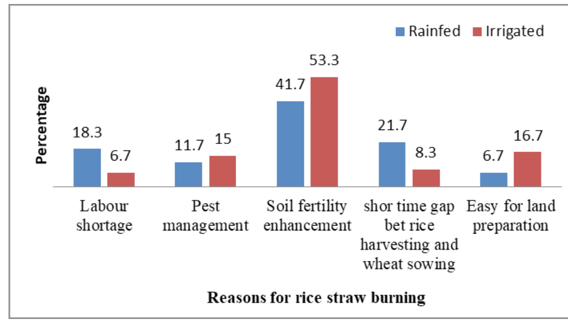

Figure 2 (b). Reasons for rice straw burning under rainfed and irrigated condition in Rupandehi, Nepal

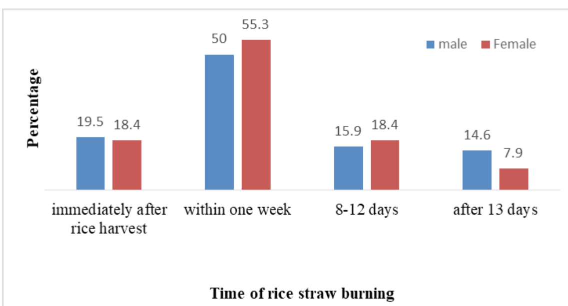

Figure 3 (a). Time of rice straw burning with respect to gender in Rupandehi, Nepal

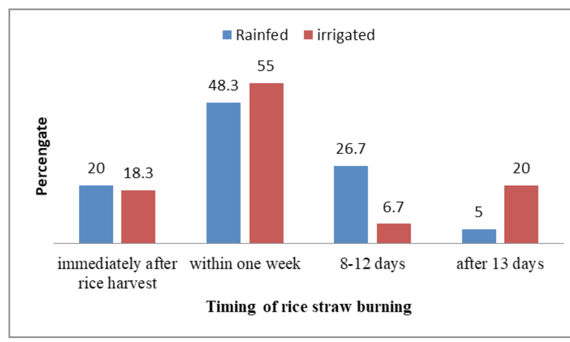

Figure 3 (b). Time of rice straw burning with respect to irrigated and rainfed condition in Rupandehi, Nepal

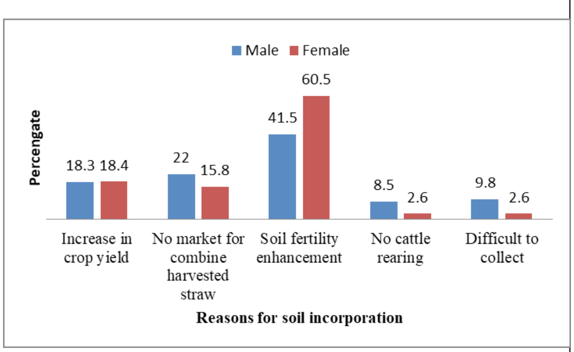

Figure 4 (a). Reasons for soil incorporation of rice straw with respect to gender in Rupandehi, Nepal

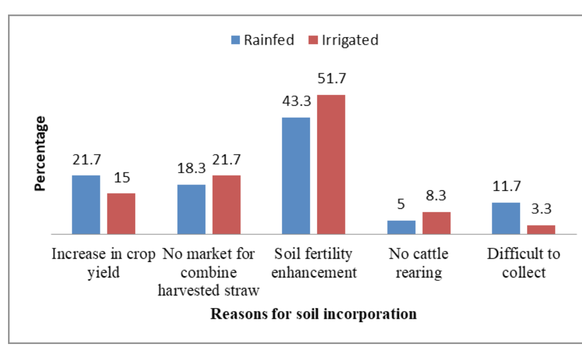

Figure 4 (b). Reasons for soil incorporation of rice straw with respect to irrigated and rainfed condition in Rupandehi, Nepal

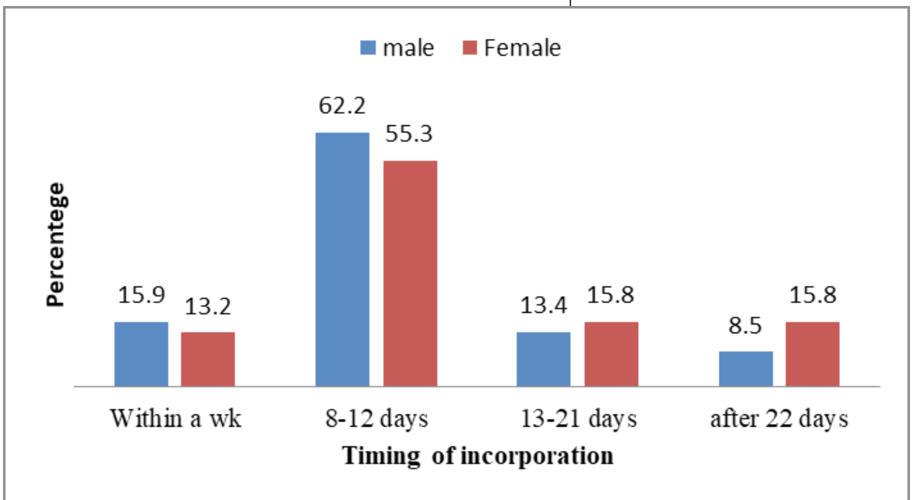

Figure 5. Time of soil incorporation of rice straw with respect to gender in Rupandehi, Nepal

CONCLUSION

Tight harvesting and sowing schedule, labour shortage, and crop residue unaddressed by combine harvester leads to the burning of rice straw within a week of harvesting rice. The misconception regarding soil fertility enhancement as a result of straw burning need to be addressed through various ways including training, visits and media. Demerits namely loss of essential plant nutrients and deteriorated soil structure outweigh few benefits that straw burning provides to the farmers. Finally, soil incorporation of rice straw is suggested to return nutrients and soil organic carbon to the soil provided all other conditions such as soil moisture, aeration, recommended dose of fertilizers with extra dose of nitrogen is facilitated so that decomposition of the straw occurs and immobilization of nitrogen is reduced.

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