ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 50(1): 77-85, March 2025

IMPROVEMENT OF SOIL PROPERTIES AND SEED YIELD OF MUSTARD AS INFLUENCED BY RICE STUBBLE *IN-SITU* BURN ASH

M. I. NAZRUL[1]

Abstract

On-farm research was conducted at low land areas located at 24° 06' N and 91° 17' E with elevation of 5-8 m under Habigonj district during winter in consecutive years of 2020-21 and 2021-2022, respectively. Five rice stubble management practices viz., T_1: rice straw burn + no tilth (Control), T_2: rice straw burn + no tilth + water spray, T_3: rice straw burn + one tilth, T_4: rice stubble burn + two tilths and T_5: common practice was evaluated in mustard cultivation. The experiment was setup in randomized complete block design with three replications. The mustard seed was sown in broadcast method. One of the locally popular broadcasts *Aman* rice cultivars (viz. Gota, Lucky, Kashi) followed by mustard var. BARI Sarisha-14 were used in this trial. The practice rice straw burn + soil tilth twice could be the good option for better seed yield of mustard with higher marginal benefit cost ratio.

Key words: Deep water rice, Straw management practices, Soil tilth, Mustard yield

Introduction

Mustard (*Brassica* spp) under Brassicaceae family is the most important oil crops in the world after soybean and groundnut (FAO, 2012). In Bangladesh, more than twenty mustard based cropping patterns (CPs) covering over 6% of the net cropped area (Nasim *et al*., 2017) of which broad cast *Aman* rice (Gota, Lucky, Kasha) followed by mustard containing CPs widely practices in low land areas. Mustard is being cultivating either monocrop or in cropping patterns under AEZ 20 of Surma-kushiyara floodplain soils (Nazrul and Akkas Ali., 2020; Ahmed and Kashem. 2017; Nazrul, 2020). The broadcast *Aman* rice followed by mustard cultivation is an important rotation in low lying areas of Sylhet region and extended to Brahmanbaria under AEZ 21. Straw is significant for organic substances to most rice growing farmers contain about 40, 35, 85, and 50% of N, P, K and S, respectively taken up by rice, rest remains in vegetative plant parts at crop maturity (Dobermann and Fairhurst, 2002). Straw is either removed from the field, burned in situ, piled or spread in the field, incorporated into soil, or used as mulch for the following crop. The removal of straw from the field is widespread in India, Bangladesh, and Nepal (Dobermann and Fairhurst, 2002).

[1]Principal Scientific Officer, On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI), Sylhet, Bangladesh.

In paddy based cropping systems, huge quantities of rice straw are left for disposal after harvest (Sidhu and Beri, 2008; Jusoh *et al*, 2013) and most of this remains unutilized in the field. Management of paddy straw (6-8 t ha^{-1}) in fields is a serious problem (Chauhan *et al*., 2012). About 80% of rice straw produced is being burnt annually in just 3 to 4 weeks during October-November in between the rice harvest and wheat sowing in India (Sehgal *et al*., 1999). Rice stubble burning has advantages in terms of farm operations but disadvantages from an environmental perspective. The burning process eliminates many pathogens, and the practice is less laborious than straw incorporation (Kutcher and Malhi, 2010; Mendoza and Samson, 1999). In-situ burn changed the physicochemical properties of soil and affect the structure of soil bacterial communities due to the properties of rice straw ash (Luo *et al.,* 2017). The ash causes changes in the soil pH, affecting the abundance of soil microorganisms (Zhao *et al.,* 2017) due to changes in nitrogen, phosphorus, and potassium levels. Burning causes atmospheric pollution and results in nutrient loss, but it is a cost-effective method of straw disposal and helps reduce pest and disease populations (Dobermann and Fairhurst 2002).

Therefore, an appropriate in-situ burn rice straw ash management is required for enhancing the system productivity of broadcast *Aman* rice-mustard pattern with a view of changing physio-chemical properties of soil.

Materials and Methods

On-farm trial was conducted at low land areas located at 24° 06' N and 91° 17' E with elevation of 5-8 m under Habigonj district during winter in consecutive years of 2020-21 and 2021-2022 in Sylhet Basin under the Agro-Ecological Zone (AEZ-21). However, five rice stubble management practices viz. T_1: rice straw burn + no tilth (Control), T_2: rice straw burn + no tilth + water spray, T_3: rice straw burn + one tilth, T_4: rice stubble burn + two tilths and T_5: common practice (straw removed from field before plough) was evaluated in mustard cultivation. The experiment was setup in randomized complete block design with three replications. The mustard seed was sown in broadcast method and each unit plot size was 20 m^2. Locally popular broadcast *Aman* rice cultivars (viz. Gota, Lucky, Kashi) was followed by mustard var. BARI Sarisha-14 was used. The soils of experimental area are grey silty clay loams, acidic in nature, topsoil quickly becomes dry during winter with medium to high level of soil fertility. During experimentation the pre-and-post soil samples were collected from trial plots and then sent to the laboratory of Soil Resource Development Institute (SRDI), Sylhet to perform chemical analysis, and the methods viz. core sampler, volumetric and gravimetric have been used for measuring the bulk density (gcm^{-3}), porosity (%) and moisture content (%) of soil, respectively.

The monthly temperature, rainfall, relative humidity, and visibility of experimental site has been presented in Figure 1. The two years average climatic data of experimental site shows that the minimum and maximum temperature was 12.82

and 35.31 0^C in the months of January and April, respectively. The rainfall of the area was uni-modal, usually occurring during April to October, and the highest precipitation of 480.93 mm occurred in June, whereas in November no rain at all and the lowest amount of rainfall occurs in January followed by February. Monson starts in April and continue to October.

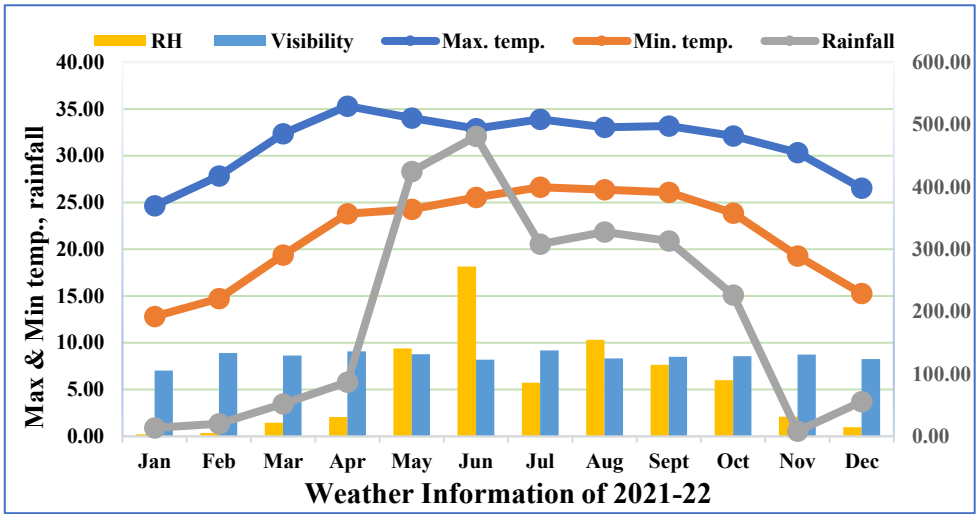

Fig. 1. Average of two years (2021-22) weather information of experimental site.

The experimental plots were tilth by power tiller followed by laddering and *Aman* seeds was broadcasted in first to second week of April depending on the set off sufficient rainfall. Due to rain fed cultivation, no irrigation was provided or even any weeding was done during cultivation. The rice harvesting was started from October last week to first week of November of each year. After harvest, rice straw remains left in the field for 3-5 days to air dry thereafter set fire normally at noon when the ash becomes cool at afternoon; the mustard seeds have been sown over the ash. No weeding and irrigations were provided. But insecticide viz., Fighter 2.5 EC @ 1 ml/L and fungicide Rovral 50 wp @ 2g/L of water was sprayed once at pod setting stage for preventing pod borer and leaf blight diseases.

The crop was fertilized with 95-35-42-7-1 kg ha^{-1} of NPKSB, respectively as basal dose. The fertilizer nutrients were used in the form of Urea, TSP, MoP, Gypsum and Boric acid. Half of urea and all of TSP, MoP, Gypsum and Boric acid were applied at 10-15 days after sowing (DAS) of mustard seeds. Remaining half of urea was applied at 20-25 DAS in top dress at the time of flowering. Mustard was harvested in first week of February. Data on yield and yield components were collected from 10 plants selected at random in each plot and seed yield was recorded plot wise. The collected data were analysed statistically using "STAR" software package and means were separated by using LSD test.

Results and Discussion

Soil physical and chemical properties

There were no significant differences in bulk density, porosity, soil pH, % organic matter, and the levels of S, Zn and B after two years after experimentation (Table1). At a depth of 0-15 cm, the highest soil moisture (22.19 %) was found in T_4, where rice straw was burn followed by soil was tilth twice before sowing of mustard seeds. Significantly, the highest per cent of N, P and K was detected in post burning soil samples collected from T_4 (rice stubble burn + two tilths). On the contrary, the levels of other micro-nutrients statistically unchanged compared with control and general practice along with the soil physical properties.

Table 1. Physiochemical properties of initial and post soil of experimentation 2021-23

Treatments	Bulk density (gcm^{-3})	Porosity (%)	Moisture content (%)	pH (1:1)	OM (%)	N (%)	P	K	S	Zn	B
							(meq.100g^{-1})		($\mu g\ g^{-1}$)		
T1	1.20	43.23	21.52	5.40	2.87	0.15	7.42	0.12	10.08	1.49	0.53
T2	1.23	44.24	22.15	5.30	2.89	0.17	7.51	0.13	10.15	1.52	0.54
T3	1.22	44.03	22.18	5.30	2.91	0.17	7.50	0.14	10.15	1.52	0.57
T4	1.23	44.22	22.19	5.50	2.93	0.18	7.57	0.15	10.14	1.54	0.54
T5	1.21	44.23	21.20	5.17	2.85	0.14	7.13	0.11	10.11	1.45	0.55
CV (%)	1.38	1.22	1.38	3.90	3.42	7.48	0.74	4.54	0.31	2.07	4.90
LSD (0.05)	NS	NS	1.26	NS	NS	0.02	0.10	0.01	NS	NS	NS
Initial soil status	1.23	44.16	22.17	5.37	2.91	0.17	7.53	0.14	10.15	1.53	0.55

T_1: rice straw burn + no tilth (Control), T_2: rice straw burn + no tilth + water spray, T_3: rice straw burn + one tilth, T_4: rice stubble burn + two tilths and T_5: common practice

Plant height (cm)

Plant height is one of the most important growth contributing characters for any corps which would be related on several factors like genetic makeup, nutrient availability, environmental or climatic condition, soil characteristics, regional adaptability etc. Though the plant height of mustard was non-significant, but numerically higher plant height was found in T_2 (rice straw burn + no tilth + water spray) followed by T_3 (rice straw burn + one tilth), and T_4 (rice stubble burn + two tilths), where rice straw burn ash incorporated in soil through ploughing. This indicated the influence of ashes is very prominent on making soil friable and loose for roots water to penetrate the soil deeply (Shukla and Mishra, 1986 and Yeledhalli, 2007).

Plant population $^{-2}$

Optimum sowing time, planting geometry and plant population are the important factors affecting the yield of any crops. Good tilths are an important factor

influencing the germination and seedling establishment for achieving desired populations. Different rice stubble management practices for mustard cultivation significantly affected plant populations m^{-2}. The maximum number of plant population was recorded in T_4 followed by T_2 and T_3. On the contrary, minimum plants population was observed in T_1 (Table 2).

Number of silique plant^{-1}

The maximum number of siliqua plant^{-1} (98.25) was obtained in T_4 (rice stubble burn + two tilths) which was statistically similar to that of T_3 practice. Results revealed that the treatments consist of tilth performed better and produce maximum number of siliques which might be due to proper mixture of ash into soil which helps for better soil amendment. A study reported that the highest diameter of capitulum, seeds capitulum^{-1}, and weight of 1000-seeds of sunflower was recorded in fly ash amendment soil (Kabal et al., 2015). This finding was in conformity with the findings of Rahman *et al.,* (2022) who stated that mustard var. BARI Sarisha-14 produced the highest number of siliqua plant^{-1} (81.26). This maximum number of siliques can be contributed to seed yields (Table 2).

1000-seed weight (g)

The weight of seeds expresses the size and development of individual, which is an important yield determinant and plays a decisive role in showing potentiality of a crop (Mamun *et al.,* 2014). Significant variation was observed in 1000-seed weight of mustard in different rice stubble management practices. The maximum 1000-seed weight was recorded from T_4 (3.65 g) which was statistically similar to that of T_2 followed by T_3 (Table 2). However, this yield contributing character of mustard (*Brassica napus* L.) sharply responded where rice straw burn ash incorporated to soil by ploughing beyond which these parameters decreased. Ash addition to soil improves various physical, chemical and biological properties and thereby is also beneficial for mustard plant growth with increased 1000- seed yield. This result coincides with the findings of Pani et al., (2015) on sunflower (*Helianthus annuus* L.). On the contrary, lowest weight of 1000-seeds 2.64 and 2.79 g were recorded from T_5 and T_1, respectively.

Number of seeds per siliqua

The number of seeds siliqua^{-1} was found non-significant; it was ranged from 22.00 to 25.12. The higher number (25.12) of seeds siliqua^{-1} was produced by T_4 (rice stubble burn + two tilths) followed by (23.78) T_2 (rice straw burn + no tilth + water spray). On the contrary, the rice stubble management practice viz. *rice straw burn + no tilth (Control)* gave lower number of seeds per siliqua. Islam *et al*., (2015) also reported that BARI Sarisha-14 gave higher seeds siliquae^{-1} (31) and the lowest number of seeds (12) in BARI Sarisha-11. Ahmed and Kashem (2017) reported that significantly the highest seed siliquae^{-1} was recorded in BARI Sarisha-14 (22.93) and the lowest in var. BADC-1 (9.71).

Table 2. Yield attributes of mustard under different management practices of rice stubble in pooled of 2 years (2021-22 and 2022-23)

Treat.	Plant height (cm)			Plants m^{-2}			Siliqua $plant^{-1}$			1000-seed wt. (g)			Seeds $Siliqua^{-1}$			Seed yield (tha^{-1})		
	Y1	Y2	Pooled mean	Y1	Y2	Pooled mean	Y1	Y2	Pooled mean	Y1	Y2	Pooled mean	Y1	Y2	Pooled mean	Y1	Y2	Pooled mean
T_1	79.63	80.03	79.83	18.02	19.32	18.67	87.41	87.45	87.43	2.78	2.8	2.79	19.65	22.35	21	1.19	1.25	1.22
T_2	83.33	84.01	83.67	20.35	23.03	21.69	87.25	88.35	87.8	3.5	3.62	3.56	23.69	23.87	23.78	1.49	1.57	1.53
T_3	80.67	82.43	81.55	20.67	22.67	21.67	91.41	95.35	93.38	2.94	3.02	2.98	22.93	23.87	23.4	1.4	1.5	1.45
T_4	83.59	84.25	83.92	25.18	25.5	25.34	96.83	99.67	98.25	3.57	3.73	3.65	23.68	26.56	25.12	1.66	1.8	1.73
T_5	79.07	80.93	80	21.08	21.58	21.33	85.98	87.36	86.67	2.46	2.82	2.64	20.64	23.36	22	1.13	1.25	1.19
CV (%)	3.35	4.01	3.68	8.35	7.58	9	3.46	3.53	2.8	9.88	10.35	11.5	10.98	11.55	13.24	10.21	10.87	11.93
LSD (0.05)	3.87	NS	NS	3.85	3.45	3.72	4.57	4.35	4.78	0.66	0.71	0.68	NS	3.45	NS	0.27	0.35	0.32

Note: Treat. =Treatment; Y1=2021-22; and Y2=2022-23.

Seed yield (t ha^{-1})

A significant effect on seed yields of mustard was varied with different rice straw management techniques. Seed yield is the reflection of siliqua plant^{-1}, weight of 1000-seeds and seeds siliqua^{-1}. The maximum seed yield (1.73 t ha^{-1}) was recorded in T_4 (rice stubble burn + two tilts) but statistically similar to that of T_2 (1.53 t ha^{-1}). It shows an increase of seed yields under rice straw burn + two tilths (T_4), over other cultivation practices; it might be due to fact that the rice straw burn ash more properly mixed with soil and helps to conserve moisture and increases the levels of N P and K in soils. The seed yield of mustard was found to increase significantly due to incorporation of rice straw burn ashes compared to control and common practice. This is the combined effect of ash and tilth practices.

Financial analysis

The economic returns from mustard cultivation under different rice straw management practices were furnished in Table 3. The practices rice straw burn + two tilths) performed better and contributed higher gross return of Tk. 121100 ha^{-1} with higher variable cost. As such, the treatment T_4 and T_2 showed very close marginal benefit cost ratio (MBCR) of 6.18 and 6.16, respectively. Total cost was varied due to variation of excess operational costs.

Table 3. Cost benefit analysis of mustard under different *in-situ* management practices of rice stubble for two years of experimental results (based on pooled mean values)

Treatments	Gross return (Tk. ha^{-1})		Variable cost (Tk. ha^{-1})		Marginal benefit cost ratio (MBCR)
	Actual	over control	Actual	over control	
T_1	84000	0	51280	0	0
T_2	107100	23100	55030	3750	6.16
T_3	101500	17500	54280	3000	5.83
T_4	121100	37100	57280	6000	6.18
T_5	83300	-7000	59530	8250	-0.85

T_1: rice straw burn + no tilth (Control), T_2: rice straw burn + no tilth + water spray, T_3: rice straw burn + one tilth, T_4: rice stubble burn + two tilths and T_5: common practice

Mustard seed: Tk. 70 kg^{-1}

Conclusion

The rice stubble management practice has some impact on soil moisture (%), chemical composition (N, P, & K) but nutrients of soil (S, Zn, B) do not affect the seed yield of mustard. The practices, rice straw burn + soil tilth twice (T_4) and rice straw burn + no tilth + water spray (T_2) could be the good option for better seed

yield of mustard with higher marginal benefit cost ratio in low land areas by managing the rice straw with burn process.

References

Ahmed, Z., and M. Kashem. 2017. Performance of mustard varieties in haor area of Bangladesh. *Bangladesh Agron. J.* 20(1): 1-5 https://doi.org/10.3329/baj.v20i1.34875

Chauhan, B. S. and S. B. Abugho. 2012. Interaction of rice residue and PRE herbicides on emergence and biomass of four weed species. *Weed Technology* 26: 627-632.

Dobermann, A., and T. H. Fairhurst. 2002. Rice straw management. Better Crops International. Vol. 16, Special Supplement. https://www.researchgate.net/publication/228850474.

FAO (Food and Agriculture Organization). 2012. Production Yearbook. Food and Agriculture Organization of the United Nations, Rome. Italy.

Islam, M. N., M. S. Rahman, M. S. Alom, M. Akhteruzzaman. 2015. Performance of different crops productivity enhancement through adaptation of crop varieties at Charland in Bangladesh. *Bangladesh Journal of Agricultural Research* 40(4):629-640.

Jusoh, M. L. C., L. A. Manaf, P. A. Latiff. 2013. Composting of rice straw with effective microorganisms (EM) and its influence on compost quality. *Iranian J. of Environmental Health Sciences and Engineering* 10(17): 1-7.

Kabal, S. G., S. M. Sukhdev, and Z. L. Newton. 2015. Wood Ash Improved Soil Properties and Crop Yield for Nine Years and Saved Fertilizer. *Journal of Agricultural Science*; 7 (12): 72-83. doi:10.5539/jas.v7n12p72

Kutcher, H. R., S. S. Malhi. 2010. Residue burning and tillage effects on diseases and yield of barley (Hordeum vulgare) and canola (Brassica napus). *Soil Tillage Res.* 109 (2), 153–160.

Luo X, Han S, Lai S, Huang Q, Chen W. Long-term straw returning affects Nitrospira-like nitrite oxidizing bacterial community in a rapeseed-rice rotation soil. J Basic Microbiol. 2017 Apr;57(4):309-315. doi: 10.1002/jobm.201600400. Epub 2016 Nov 25. PMID: 27885690.

O, X.S., S. Han, S. S. Lai, Q. Y. Huang, W. L. Chen. 2017. Long-term straw returning affects Nitrospira-like nitrite oxidizing bacterial community in a rapeseed-rice rotation soil. *J. Basic Microbiol.* 309-315.

Mamun, F., M. H. Ali, I. F. Chowdhury, M. Hasanuzzaman, M. A. Matin. 2014. Performance of Rapeseed and Mustard Varieties Grown Under Different Plant Density. *Sci. Agri.* 8 (2): 70-75

Nasim, M., S. M. Shahidullah, A. Saha, M. A. Muttaleb, T. L. Aditya, M. A. Ali, and M. S. Kabir. 2017. Distribution of crops and cropping patterns in Bangladesh. *Bangladesh Rice J.* 21 (2): 1-55.

Nazrul, M. I. 2020. On-farm evaluation of improved pattern through inclusion of mustard in fallow period preceding T. *Aus*-T. *Aman* rice cropping in Sylhet region. *Bangladesh Agron. J.*, 22(2): 1-10. https://doi.org/10.3329/baj.v22i2.47616

Nazrul, M. I. and M. Akkas Ali. 2020. On-farm adaptation of some oilseed crops under acidic soil of Sylhet region in Bangladesh. *Bangladesh Agron. J.* 23(2): 87-95

Pani, N. K., P. Samal, R. Das, S. Sahoo. 2015. Effect of fly ash on growth and yield of sunflower (*Helianthus annuus* L.), *Int. J. Agri. & Agri. R*., Vol. 7(2) p. 64-74.

Rahman, M., M. K. Shahadat, T. Z. Munmun, S. Kobir, A. R. Maukeeb, F. A. Nasim, and H. Rashid. 2022. Performance of mustard varieties under saline prone areas of Bangladesh. *African Journal of Agricultural Research*, 18(8): 608-616. https://doi.org/10.5897/AJAR2022.15955

Sehgal, V. K., M. Arora and S. Arora. 1999. Paddy Straw- A Valuable Waste. Souvenir, Annual Day of ISAE (Punjab Chapter), College of Agril. Eng., Punjab Agricultural University, Ludhiana, India, 26 February 1999, pp 10-16.

Shukla, K. N. and L. C. Mishra. 1986. Effect of fly ash extract on growth and development of corn and soybean seedlings. *Water Air Soil Pollut* 27: 155-167

Sidhu, B. S. and V. Beri. 2008. Rice residue management: farmers' perspective. *Indian Journal of Air Pollution Control* 8(1): 61-67.

Yeledhalli*,* N. A.*,* S. S. Prakash*,* S. B. Gurumurthy *and.* M. V. Ravi. 2007. Coal fly ash as modifier of physic-chemical and biological properties of soil. *Karnataka Journal of Agricultural Sciences* 20 (3): 531-534.

Zhao, J., T. Ni, W. Xun, X. Huang, Q. Huang, W. Ran, B. Shen, R. Zhang, Q. Shen. 2017. Influence of straw incorporation with and without straw decomposer on soil bacterial community structure and function in a rice-wheat cropping system. *Appl. Microbiol. Biotechnol.* 101: 4761-4773.