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Research Article

Effect of *in situ* soil moisture conservation practices on maize and its crop residue incorporation on yield and economics of succeeding transplanted rice *Var.* ADT 46

Gudapati Ashoka Chakravarthy
Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar - 608002 (Tamil Nadu), India
M. Thiruppathi*
Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar - 608002 (Tamil Nadu), India
S. Kandasamy
Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar - 608002 (Tamil Nadu), India
K. Dhanasekaran
Department of Soil Science & Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Annamalai Nagar - 608002 (Tamil Nadu), India

*Corresponding author. E mail: agropathy@gmail.com

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Abstract
Crop residue incorporation is a key component of sustainable cropping systems. It reduces the adverse effects of residue burning and enhances soil fertility. Effective usage of crop residue in the field and proper management are required. With this background, a field experiment was conducted during 2020 – 21 in the maize-rice cropping sequence at Annamalai University Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu to find out the residual effect of different mulching practices adopted in preceding maize crop and maize stubble incorporation on the growth, yield and economics of transplanted rice *Var.* ADT 46. The field experiment was conducted in Factorial Randomized Block Design with three replications. In factor I, soil moisture conservation in preceding maize crop *viz.,* mulching of sugarcane trash, water hyacinth, hydrogel and control were allotted. In factor II, different levels of maize crop stubble incorporation on rice *viz.,* 0, 33, 66 and 100% were provided. Water hyacinth mulched plot (M_3) to the preceding crop registered significantly (þ <0.05) higher yield parameters, yield and economic returns of succeeding rice. The lower values were observed in unmulched (M_1) plot. With respect to maize crop stubble incorporation on rice crop, the incorporation of 66% (SI_3) of maize stubble registered higher yield parameters, yield and economic returns. In the interaction effects, mulching with water hyacinth to preceding maize + maize crop stubble incorporation at 66% in rice crop (M_3SI_3) recorded significantly (þ <0.05) higher yield parameters, yield and economic returns than other treatments. The lowest values were recorded with an unmulched + 100% crop residue incorporated (M_1SI_4) plot. Mulching the preceding maize crop with water hyacinth at a rate of 12 t ha-1 and incorporating 66% maize stubble into the transplanted rice (M_3SI_3) had a remarkable yield advantage and financial rewards.

Keywords: Economics, Mulch, Residue incorporation, Rice yield

INTRODUCTION

Incorporation of crop residue in the field is considered one of the important key factors in promoting physical, chemical and biological attributes of soil health in agricultural systems as an alternative to organic amendments. The readiest and most accessible form of biomass is crop residue, the biomass that remains in the field after a crop is harvested. The residue derived from crops is considered the greatest source of soil organic matter (Urra *et al.*, 2019) for agricultural soils. Among the major cereal crops that produce large amounts of crop residue are maize (*Zea mays* L.), wheat (*Triticum aestivum* L.), sorghum (*Sorghum bicolor* L.) and rice

(*Oryza sativa* L.) (Blanco-Canqui *et al.,* 2006). Incorporation of crop residues plays an important role in replenishing soil nutrient stocks (Gojiya *et al.,* 2019), increase in soil microbial composition (Coonan *et al.,* 2020), soil organic matter and improving soil fertility, improving soil quality and reducing the nutrient inputs (Fang *et al.,* 2018), creating a soil regime favorable for root development and resulting in higher crop yields (Memon *et al.,* 2018), thus contributing to sustainable rice production (Li *et al.,* 2020). Crop residue incorporation is a promising alternative to open-field burning that harms air quality and human health (Porichha *et al.,* 2021). Therefore, residue incorporation should be strongly recommended in crop production (Kumar *et al.,* 2021).

Crop residue incorporation is an important component of environmental protection; residues with high lignin content contribute to soil carbon sequestration and lower CO_2 effluxes in the soil (Leal *et al.,* 2020). Residue incorporation has the potential to mitigate the global increase in atmospheric greenhouse gases (Allen *et al*., 2020). Therefore, crop residue retention should be promoted for the improvement of soil quality and the health of the environment (Bhuvaneshwari *et al.,* 2019).

Maize has a high ratio of straw to grain weight (2:1) (Gao *et al*., 2009). Interestingly, the soil pH significantly decreases with maize residue retention (Nyambo *et al.,* 2018), largely due to the organic acid and CO_2 derived from the residues by microbial growth; the decreased soil pH resulted in the greater availability of soil nutrients and an improvement in maize growth. Management practices adopted in the preceding crop and their residual effects have greatly influenced the growth and yield of the succeeding crop. Adoption of modern high-yielding rice variety in the intensive cropping system, there is a great demand for soil nutrients and other applied nutrients, which limits the availability and uptake of nutrients and final yield (Thiruppathi, 2017). Keeping these in view, an experiment was conducted to determine the impact of soil mulching on the preceding maize crop and the levels of maize crop stubble incorporation on transplanted rice *var.* ADT 46.

MATERIALS AND METHODS

A field experiment was conducted at Annamalai University Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India, during *rabi* (August to January) 2020-2021. Geographically this site was situated at 11° 24' N latitude, 74° 41' E longitude, with an altitude of +5.79 m above mean sea level and 15 km away from the East coast of Bay of Bengal. The mean annual rainfall received 1541 mm with a distribution of 1061 mm during North-East monsoon (Oct-Dec), 244 mm during South - West monsoon (June-Sep), 53 mm during winter (Jan- Feb) and 183 mm as summer showers (March -May) spreading over 52 rainy days. The mean relative humidity is 87 per cent. The soil of the experimental field is representative of the Kondal typic series. The soil was moderately clay with a pH of 7.08. The rice variety ADT 46 medium duration (135 days) was used as test crop. The seedlings of 30 days old were transplanted in the main field by adopting a spacing of 20 x 10 cm. The experiment was laid out in factorial randomized block design and consisted of two factors with three replications. In factor I, soil moisture conservation practices adopted in preceding maize crop *viz.,* M_1 – No mulched, M_2 - Sugarcane trash at 10 t ha^{-1}, M_3 - Water hyacinth at 12 t ha^{-1} and M_4 – Hydrogel 10 kg ha^{-1} were taken. In factor II, maize crop stubble incorporation at different levels were adopted in rice *viz.,* SI_1 - 0% maize stubble incorporation, SI_2 - 33% maize stubble incorporation, SI_3 - 66% maize stubble incorporation and SI_4- 100% maize stubble incorporation. Bio composter (mixture of microbes) was spread on the stubbles at the time of incorporation to all the plots @ 4 lit ha^{-1} for fast decomposition of previous crop residue. All other crop management practices were followed as per the recommendation of Department of Agriculture, Government of Tamil Nadu. The data on the number of productive tillers m^{-2}, number of filled grains $panicle^{-1}$, test weight (1000 grain weight), grain yield ha^{-1} and straw yield ha^{-1} were calculated and tabulated from each treatment. Cost of cultivation, gross return, net return and benefit cost ratio were also worked out to evaluate the economics of each treatment, based on the existing market prices of inputs and output. The field data's statistical analysis was carried out per the methodology by Gomez and Gomez (2010). The critical differences were worked out at 5 per cent probability level, wherever the results were significant.

RESULTS AND DISCUSSION

Yield parameters

The data on yield parameters of succeeding rice crop is presented in Table 1. The yield parameters of succeeding rice crop exhibited significant (þ <0.05) effect by mulching to the preceding crop and stubble incorporation at different levels. However, test weight was not significantly (þ <0.05) affected by mulching materials and crop stubble incorporation both in individual as well as in combinations.

Among the different mulching materials applied to the preceding maize crop, water hyacinth mulched at 12 t ha^{-1} (M_3) the registered maximum number of panicles (328 m^{-2}) and a number of filled grains (83 $panicle^{-1}$) of transplanted rice. This was followed by the application of sugarcane trash mulched at 10 t ha^{-1} (M_2). The least number of panicles (291 m^{-2}) and a number of filled

Table 1. Effect of soil moisture conservation and different levels of stubble incorporation on yield attributes of transplanted rice

Treat-ments	Number of panicles m^{-2}					Number of filled grains $panicle^{-1}$					Test weight (1000 grain weight)				
	SI_1	SI_2	SI_3	SI_4	Mean	SI_1	SI_2	SI_3	SI_4	Mean	SI_1	SI_2	SI_3	SI_4	Mean
M_1	281	313	319	251	291	64	73	79	56	68	22.90	22.60	22.90	22.80	22.80
M_2	321	326	328	314	322	80	82	83	74	80	22.70	22.80	23.10	22.50	22.78
M_3	322	327	351	313	328	81	83	91	76	83	22.80	22.90	22.90	22.50	22.78
M_4	283	313	320	255	293	64	72	80	56	68	22.80	22.80	22.80	22.80	22.80
Mean	302	320	330	283		72	78	83	66		22.80	22.78	22.93	22.65	
		SE_D	CD (p=0.05)				SE_D		CD (p=0.05)			SE_D		CD (p=0.05)	
M		4.28	8.75			M	1.03		2.11		M	0.32		NS	
SI		4.28	8.75			SI	1.03		2.11		SI	0.32		NS	
M x SI		8.57	17.5			M x SI	2.07		4.23		M x SI	0.63		NS	

M_1 – Control, M_2 - Sugarcane trash @ 10 t ha^{-1}, M_3 - Water hyacinth @ 12 t ha^{-1}, M_4 - Hydrogel @ 10 kg ha^{-1}; SI_1 - 0% incorporation of maize stubbles, SI_2 - 33% incorporation of maize stubbles, SI_3 - 66% incorporation of maize stubbles, SI_4 -100% incorporation of maize stubbles

grains (68 $panicle^{-1}$) were recorded in the no mulched (M_1) plot and this was on par with hydrogel applied at 10 kg ha^{-1} (M_4). The increase in yield attributes due to water hyacinth mulched to the preceding crop as a result of enhanced soil productivity, that increased the soil organic carbon content, soil microbial load that ultimately improved soil crumb structure and nutrient available status to the succeeding crop and resulted in enhanced yield parameters of the rice crop. The results are in line with Alam *et al*. (2017) stated that water hyacinth served as quality bio manure for improving soil fertility and consequently favoured to produce a higher yield in potato crop.

Irrespective of the different levels of maize crop stubble incorporation, the incorporation of 66% of maize crop stubbles (SI_3) recorded a significantly maximum number of panicles (330 m^{-2}) and a number of filled grains (83 $panicle^{-1}$). This was followed by the incorporation of maize stubbles at 33% (SI_2). The least number of panicles (283 m^{-2}) and a number of filled grains (66 $panicle^{-1}$) were recorded with the incorporation of 100% maize crop stubble (SI_4). This might be due to the decomposition of organic matter by microorganisms, which utilize carbon as an energy source and make the essential nutrient available for plant growth and development. Similar findings are concorded with Tomer *et al*. (2021), who showed that the application of organic mulches has an important long-term effect on the availability of essential elements to the growing plants.

Interaction effect of different soil mulches applied to preceding maize crop and its stubbles incorporated at different levels revealed that water hyacinth mulched at 12 t ha^{-1} to preceding maize crop and incorporation of maize stubbles at 66 % (M_3SI_3) registered significantly more number of panicles (351 m^{-2}) and number of filled grains (91 $panicle^{-1}$). This was followed by sugarcane trash mulch at 10 t ha^{-1} and the incorporation of maize stubbles at 66% (M_4SI_3). The least number of panicles (281 m^{-2}) and a number of filled grains (64 $panicle^{-1}$) were recorded with no mulched plot + 100% maize stubble incorporation (M_1SI_4). The increased number of yield parameters might be due to the quantity of available nutrients, improved water holding capacity of the soil and neutral soil pH. The decomposition of organic matter leads to the production of organic acids that have neutralized the soil pH, and improved the water holding capacity and available nutrients in wheat crop, as reported by Dhar *et al*. (2014).

Grain and straw yield

The data on yield of succeeding rice crop is presented in Table 2. Yield of succeeding rice crop had a significant influence as the result of integration of mulching materials of the preceding crop and its stubble incorporation at different levels. Among the different mulching materials applied to the preceding maize crop, water hyacinth mulched at 12 t ha^{-1} (M_3) registered maximum grain yield (5182 kg ha^{-1}) and straw yield (8798 kg ha^{-1}). This was followed by sugarcane trash mulched at 10 t ha^{-1} (M_2). The lesser grain yield (3853 kg ha^{-1}) and straw yield (7829 kg ha^{-1}) were recorded in control (M_1) and this was on par with hydrogel applied at 10 kg ha^{-1} (M_4). It was due to the faster decomposition of water hyacinth as it contains high nitrogen, phosphorus, and potassium elements, making it appropriate for mulch in preceding crop and its residual effect on succeeding crop as manure. The results were similar to Indulekha and Thomas (2018), who indicated that water hyacinth mulch enhanced seedling survival and growth performance in plantations by aiding in soil moisture retention and by providing a source of nutrients through decomposition.

Irrespective of the different levels of maize crop stubble incorporation, the incorporation of 66% of maize crop stubbles (SI_3) recorded significantly maximum grain yield (5276 kg ha^{-1}) and straw yield (8788 kg ha^{-1}). The

Table 2. Effect of soil moisture conservation and different levels of stubble incorporation on yields of transplanted rice

Treat-ments	Grain Yield (kg ha^{-1})					Straw Yield (kg ha^{-1})				
	SI_1	SI_2	SI_3	SI_4	Mean	SI_1	SI_2	SI_3	SI_4	Mean
M_1	3586	4085	4798	2941	3853	7699	8082	8692	6845	7829
M_2	4985	5391	5521	4185	5021	8694	8668	8690	8307	8590
M_3	5041	5498	5944	4244	5182	8696	8683	9071	8742	8798
M_4	3651	4137	4839	3051	3920	7696	8269	8700	6859	7881
Mean	4316	4778	5276	3605		8196	8426	8788	7688	
		SE_D	CD (p=0.05)				SE_D	CD (p=0.05)		
M		62.37	127.39			M	114.80	234.46		
SI		62.37	127.39			SI	114.80	234.46		
M x SI		124.75	254.79			M x SI	229.60	468.92		

M_1 – Control, M_2 - Sugarcane trash @ 10 t ha^{-1}, M_3 - Water hyacinth @ 12 t ha^{-1}, M_4 - Hydrogel @ 10 kg ha^{-1}; SI_1 - 0% incorporation of maize stubbles, SI_2 - 33% incorporation of maize stubbles, SI_3 - 66% incorporation of maize stubbles, SI_4 -100% incorporation of maize stubbles

incorporation of maize stubble followed this at 33% (SI_2). The least grain yield (3605 kg ha^{-1}) and straw yield (7688 kg ha^{-1}) were recorded under the incorporation of 100% maize crop stubble into the soil (SI_4). It was due to the incorporation of stubbles that supplied essential plant nutrients, accumulate soil organic carbon and thereby maintained soil fertility status. Crop residue addition increased soil organic matter accumulation and fertility, thereby improving soil sustainability found with Ghimire *et al*. (2017).

Interaction effect between mulches applied to preceding maize crop and its stubbles incorporation at different levels water hyacinth mulched at 12 t ha^{-1} to preceding maize crop and incorporation of maize stubbles at 66% (M_3SI_3) significantly registered maximum grain yield (5944 kg ha^{-1}) and straw yield (9074 kg ha^{-1}). This was followed by sugarcane trash mulched at 10 t ha^{-1} and incorporation of maize stubbles at 66% (M_4SI_3). The least grain yield (2941 kg ha^{-1}) and straw yield (6845 kg ha^{-1}) were noticed in no mulched plot with 100% maize stubble incorporation (M_1SI_4). It was due to the cumulative and synergic effect of water hyacinth mulched on the preceding crop, which contains higher nutrients that helped to achieve higher yield. Organic mulch and stubble integration increased the soil carbon and nutrient content, resulting in enhanced growth and yield attributes, consequently producing higher yield, as mentioned by Singh *et al.* (2020).

Economics

The economics of rice cultivation are furnished in Table 3. The total cost of cultivation varied between Rs. 42376 ha^{-1} to Rs. 44376 ha^{-1}. Among the different soil moisture conservation practices adopted for the preceding crop, the plot that received water hyacinth mulch at 12 t ha^{-1} (M_3) registered a higher gross return

Table 3. Effect of soil moisture conservation and different levels of stubble incorporation on economics of transplanted rice

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross Return (Rs. ha^{-1})	Net Return (Rs. ha^{-1})	Benefit Cost Ratio (BCR)
M_1SI_1	44376	72247	27871	1.63
M_1SI_2	43776	81612	37836	1.86
M_1SI_3	43076	95056	51980	2.21
M_1SI_4	42376	59783	17407	1.41
M_2SI_1	44376	98424	54048	2.22
M_2SI_2	43776	105706	61930	2.41
M_2SI_3	43076	108068	64992	2.51
M_2SI_4	42376	83637	41261	1.97
M_3SI_1	44376	99434	55058	2.24
M_3SI_2	43776	107647	63871	2.46
M_3SI_3	43076	116063	72987	2.69
M_3SI_4	42376	85134	42758	2.01
M_4SI_1	44376	73414	29038	1.65
M_4SI_2	43776	82735	38959	1.89
M_4SI_3	43076	95802	52726	2.22
M_4SI_4	42376	61777	19401	1.46

M_1 – Control, M_2 - Sugarcane trash @ 10 t ha^{-1}, M_3 - Water hyacinth @ 12 t ha^{-1}, M_4 - Hydrogel @ 10 kg ha^{-1}; SI_1 - 0% incorporation of maize stubbles, SI_2 - 33% incorporation of maize stubbles, SI_3 - 66% incorporation of maize stubbles, SI_4 -100% incorporation of maize stubbles of Rs. 99434 ha^{-1}, net return of Rs. 55058 ha^{-1} and benefit-cost ratio of 2.24. This was followed by sugarcane trash mulch at 10 t ha^{-1} (M_3). In comparison, the least economic returns were recorded in the no mulched plot (M_1).

Regarding different levels of maize crop stubble incorporation to rice crop, incorporation of 66% of maize crop stubbles (SI_3) observed higher gross return of Rs. 95056 ha^{-1}, net return of Rs. 51980 ha^{-1} and benefit-cost ratio of 2.21. Incorporation of 100% of maize stubbles registered minimum value of economics.

Adoption of soil moisture conservation technique, *i.e.,* water hyacinth mulch at 12 t ha^{-1} to the preceding crop and soil incorporation of maize stubble at 66% (M_3SI_3) recorded a higher gross return of Rs. 116063 ha^{-1}, net return of Rs. 72987 ha^{-1} and benefit-cost ratio of 2.69. The minimum gross return of Rs. 59783 ha^{-1}, the net return of Rs. 17407 ha^{-1} and the benefit-cost ratio of 1.41 were observed in no mulch plot + 100% maize stubble incorporation (M_1SI_4). The higher yield might be due to the higher nutrient status in the water hyacinth, easy decomposition, increase in microbial activity in the soil and optimum quantity of stubble incorporation enabled to achieve higher nutrient availability that resulted in better growth. These yield attributes ultimately produced a higher yield. It maintained a congenial soil environment in the root zone throughout the crop growth period by integrating water hyacinth and maize stubbles. This, in turn, was reflected in higher yield components and contributed to maximum grain yield in water hyacinth treatments as reported by Chowdhury *et al*. (2021).

Conclusion

From the present field experiments, it was concluded that water hyacinth mulched at 12 t ha^{-1} to the preceding crop and soil incorporation of maize stubble at 66% (M_3SI_3) was effective practice for getting higher yield and economic benefits to the rice farmers.

Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. Alam, A., Srivastava, S.K., Anand, K., Sinha, P.B. & Mishra, P.K. (2017). Response of water hyacinth as a source of potassium in the production of potato. *Int. J. Innovative Res. in Science, Engineering and Technology*, *6*(7), p.10. DOI:10.15680/IJIRSET.2017.0607294
2. Allen, J., Pascual, K. S., Romasanta, R. R., Trinh, M. V., Thach, T. V., Hung, N. V. & Chivenge, P. (2020). Rice straw management effects on greenhouse gas emissions and mitigation options. In *Sustainable Rice Straw Management* (pp. 145-159). Springer, Cham. https://doi.org/10.1007/978-3-030-32373-8_9
3. Bhuvaneshwari, S., Hettiarachchi, H. & Meegoda, J. N. (2019). Crop residue burning in India: policy challenges and potential solutions. *Int. J. Environ. Res. Public Health*, *16*(5), 832. https://doi.org/10.3390/ijerph16050832
4. Blanco-Canqui, H., Lal, R., Post, W. M., Izaurralde, R. C. & Owens, L. B. (2006). Rapid changes in soil carbon and structural properties due to stover removal from no-till corn plots. *Soil science*, *171*(6), 468-482.doi: 10.1097/01.ss.0000209364.85816.1b
5. Chowdhury, S., Bolan, N., Farrell, M., Sarkar, B., Sarker, J.R., Kirkham, M.B., Hossain, M.Z. & Kim, G.H. (2021). Role of cultural and nutrient management practices in carbon sequestration in agricultural soil. *Advances in Agronomy*, *166*, pp.131-196. https://doi.org/10.1016/bs.agron.2020.10.001
6. Coonan, E. C., Kirkby, C. A., Kirkegaard, J. A., Amidy, M. R., Strong, C. L. & Richardson, A. E. (2020). Microorganisms and nutrient stoichiometry as mediators of soil organic matter dynamics. *Nutrient Cycling in Agroecosystems*, *117*(3), 273-298.https://doi.org/10.1007/s10705-020-10076-8
7. Dhar, D., Ashim, D., Nirmalendu, B., Niladri, P., Shrikant, B. & Thomas, T. (2014). Residual effect of crop residues on growth, yield attributes and soil properties of wheat under rice-wheat cropping system. *Indian J. Agriculture Res*. 48 (5): 373-378.
8. Fang, Y., Nazaries, L., Singh, B. K. & Singh, B. P. (2018). Microbial mechanisms of carbon priming effects revealed during the interaction of crop residue and nutrient inputs in contrasting soils. *Global Change Biology*, *24*(7), 2775-2790. https://doi.org/10.1111/gcb.14154
9. Gao, LW., Ma, L., Zhang, WF., Wang, FH., Ma, WQ. & Zhang, FS. (2009) Estimation of nutrient resource quantity of crop straw and its utilization situation in China. T Chinese Soc Agric Eng 25:173–179.
10. Ghimire, R., Lamichhane, S., Acharya, B. S., Bista, P. & Sainju, U. M. (2017). Tillage, crop residue, and nutrient management effects on soil organic carbon in rice-based cropping systems: A review. *J. integrative agriculture*, *16* (1), 1-15. https://doi.org/10.1016/S2095-3119(16)61337-0
11. Gojiya, A., Deb, D. & Iyer, K. K. (2019). Feasibility study of power generation from agricultural residue in comparison with soil incorporation of residue. *Renewable Energy*, *134*, 416-425. https://doi.org/10.1016/j.renene.2018.11.003
12. Gomez, K. A. and Gomez, A. A. (2010). Statistical procedures for agricultural research (2nd ed), John Wiley and Sons, New York, Pp 97-107.
13. Indulekha, V.P. & Thomas, C.G. (2018) Utilization of water hyacinth as mulch in turmeric. J. Trop. Agric. 56, 27–33.
14. Kumar, M., Mitra, S., Mazumdar, S. P., Majumdar, B., Saha, A. R., Singh, S. R. & Hossain, A. (2021). Improvement of soil health and system productivity through crop diversification and residue incorporation under jute-based different cropping systems. *Agronomy*, *11*(8), 1622. https://doi.org/10.3390/agronomy11081622
15. Leal, O. A., Amado, T. J., Fiorin, J. E., Keller, C., Reimche, G. B., Rice, C. W. & Schwalbert, R. (2020). Linking Cover Crop Residue Quality and Tillage System to CO2-C Emission, Soil C and N Stocks and Crop Yield Based on a Long-Term Experiment. *Agronomy*, *10*(12), 1848. https://doi.org/10.3390/agronomy10121848

16. Li, Z., Zhang, X., Xu, J., Cao, K., Wang, J., Xu, C. & Cao, W. (2020). Green manure incorporation with reductions in chemical fertilizer inputs improves rice yield and soil organic matter accumulation. *J. Soils and Sediments*, *20*(7), 2784-2793. https://doi.org/10.1007/s11368-020-02622-2
17. Memon, M. S., Guo, J., Tagar, A. A., Perveen, N., Ji, C., Memon, S. A. & Memon, N. (2018). The effects of tillage and straw incorporation on soil organic carbon status, rice crop productivity, and sustainability in the rice-wheat cropping system of eastern China. *Sustainability*, *10*(4), 961. https://doi.org/10.3390/su10040961
18. Nyambo, P., Taeni, T., Chiduza, C. & Araya, T. (2018). Effects of maize residue biochar amendments on soil properties and soil loss on acidic Hutton soil. *Agronomy*, *8* (11), 256. https://doi.org/10.3390/agronomy8110256
19. Porichha, G. K., Hu, Y., Rao, K. T. V. & Xu, C. C. (2021). Crop residue management in India: Stubble burning vs. other utilizations including bioenergy. *Energies*, *14*(14), 4281. https://doi.org/10.3390/en14144281
20. Singh, T. B., Ali, A., Prasad, M., Yadav, A., Shrivastav, P., Goyal, D. & Dantu, P. K. (2020). Role of organic fertilizers in improving soil fertility. In *Contaminants in Agriculture* (pp. 61-77). Springer, Cham. https://doi.org/10.1007/978-3-030-41552-5_3
21. Thiruppathi, M. (2017). Diversification of existing rice-based cropping system for sustained productivity under delayed onset of monsoon. *European J. Biotech. and Biosci.,* 5(4): 80-82.
22. Tomer, A., Singh, R., Singh, S.K., Dwivedi, S.A., Reddy, C.U., Keloth, M.R.A. & Rachel, R. (2021). Role of fungi in bioremediation and environmental sustainability. In *Mycoremediation and Environmental Sustainability* (pp. 187-200). Springer, Cham. https://doi.org/10.1007/978-3-030-54422-5_8
23. Urra, J., Alkorta, I. & Garbisu, C. (2019). Potential benefits and risks for soil health derived from the use of organic amendments in agriculture. *Agronomy*, *9*(9), 542. https://doi.org/10.3390/agronomy9090542