

Research Article:**COMPARATIVE STUDY OF DEEP-BEDDED PACK COMPOST RELATIVE TO ORGANIC AND INORGANIC AMENDMENTS FOR ENHANCING GROWTH AND PRODUCTIVITY OF AMAN RICE IN BANGLADESH**

Hem Raj Dhakal^{a,b}, A.K.M. Ahsan Kabir^{a*}, Zubaida Gulshan^a,
Mohammad Mukhlesur Rahman^a, Ruhul Amin^a and Rokibul Islam Khan^a

^aDepartment of Animal Science, Bangladesh Agricultural University, Mymensingh-2203, Bangladesh

^bNational Swine Research Program, Nepal Agricultural Research Council, Pakhribas, Dhankuta, Nepal

*Corresponding author: ahsankabiras@bau.edu.bd

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ABSTRACT

The deep bedded pack (DBP) system is a modern loose housing method for dairy cows that enhances comfort by providing an open-bedded area for resting and exercise. In DBP, dung and urine are mixed with bedding materials, which is cultivated 1–3 times daily. DBP compost, derived from this system, serves as an organic manure. This study evaluated the effect of DBP compost on Aman rice production. A study was initiated in Satkhira, Bangladesh, from 1st June 2020 to 31st July 2021 with five treatments as T₁: Control (no fertilizer), T₂: Chemical fertilizer (CF) as Recommended Dose (RD), T₃: Biochar + RD, T₄: DBP Compost + RD, and T₅: DBP Compost + Biochar + RD. The DBP compost had 66.47% moisture, pH 8.30, organic carbon 21.89%, total nitrogen 1.83%, C:N 13.68, phosphorus 0.29%, potassium 1.57%, and sulfur 0.3%. Most yield parameters differed significantly ($p < 0.01$) among treatments, except panicle length and grains per panicle. Biomass yield, grain yield, test weight, and percent filled grains were highest in T₅, though not significantly different from T₄. Overall, DBP compost, whether used alone or combined with biochar, proved more effective than chemical fertilizer in enhancing the growth and yield of Aman rice.

Keywords: Biochar, compost bedded pack, paddy production

INTRODUCTION

Deep bedded pack compost (DBP compost) is organic manure prepared from deep bedded pack (DBP) cattle rearing system. Deep Bedded Pack is an arrangement of rearing animals in which actively managed composting is practiced with manure, urine, washed water, and leftover forages (Damasceno, 2012). It is a housing system consisting of a large, open resting area, usually bedded with sawdust or dry, fine wood shavings and manure composted into place and mechanically stirred regularly (Leso et al., 2019; Woodford et al., 2018). Manure and urine mix into the bedding that remains in place for several months and is generally cleaned out once a year (Galama, 2011). This system was first introduced in the US in 1980, and thereafter, it is now practiced in many countries all over the world (Shane et al., 2019), but in Bangladesh, it is still entirely untouched.

Indigenous microorganisms (IMOs) are the naturally occurring soil microbes that contribute to beneficial soil effects such as nitrogen fixation, mineralization, suppress odors, humus formation, disease suppression, and decomposition of organic matter (Sanchez et al., 2018). In agriculture, the concept of using IMOs is gaining popularity as a natural and sustainable alternative to synthetic fertilizers and pesticides. The use of IMOs can enhance soil fertility, improve plant

growth, and increase crop yields, while also reducing the use of synthetic chemicals and their harmful effects on the environment. So, it can be better for faster decomposition of organic matter and enhance the manure value of DBP compost.

Inorganic fertilizer is an expensive agricultural input for smallholder farmers in Bangladesh. Most of these farmers either do not or only apply half of the recommended rate of inorganic fertilizer. Low-income, smallholder farmers would benefit from any alternative that reduced the need for inorganic fertilizer (Cen et al., 2020). Organic agriculture is a potential alternative production system where organic fertilizers can ensure safe agricultural production without harming people, soil, and the environment due to their organic contents (Anhar et al., 2016; Ferdous et al., 2021). However, over a longer period, applications of organic materials such as livestock manure and crop residues have been found to bring about a gradual improvement in soil productivity and crop performance (Ebaid et al., 2007). The major portion of the global population is dependent on agriculture, and it is very common in developing countries like Bangladesh (Laily et al., 2021). Hence, increasing safe agricultural production can help to ensure food safety and security. Rice as a major crop in Bangladesh, understanding organic fertilizer's impact on rice farms is necessary to increase the country's rice production. In this context, DBP compost may be one option.

Thus, this experiment was conducted to assess the performance of DBP compost in the growth and productivity of Aman rice in Bangladesh

RESEARCH METHODS

A study was conducted in the Satkhira district of Bangladesh. A deep bedded pack (16 inches thick) was made by using two hundred kilograms of rice husk. A total of six adult cows were used for collecting the bedding materials for making compost. All animals were drenched against internal and external parasites before the onset of the trial with regular health checkups along with ad-lib clean drinking water. Grass, straw, and concentrate feeding was done regularly. A total of 100 ft² floor space was provided to each animal. Ten kg of rice husk was added fortnightly to make the floor space dry. Similarly, 5 g of well-fermented IMO-2 paste containing total viable counts of 9.01×10^9 CFU/g was diluted with 500 ml of water and sprayed on the bedding fortnightly for faster decomposition of the bedded pack. IMOs were produced by following the IMOs production protocol (Ibrahim and Abu-Bakar, 2013), i.e., using cooked rice and molasses. Regular turning and mixing of the bedding was done to make the bedding dry. After 12 months, bedding from DBP was removed and kept in a compost pit for compost preparation. In each 7 days interval, IMO-2 was sprayed for quicker decomposition. Samples were collected after the maturation of compost. Compost is considered mature when C:N ratio is in the range 15-20:1. and different nutrient compositions were analyzed in Animal Science Lab and Soil Science Lab, Bangladesh Agricultural University.

An experiment was carried out at the experimental field of the Department of Soil Science, Bangladesh Agricultural University, Mymensingh, Bangladesh with four replications and five treatments in a Randomized Complete Block Design (RCBD). BRRI Dhan 49, a high yielding variety of Aman rice was used in the study. The total plot number was twenty and the unit plot size was 5 m×4 m, with 0.75 m inter-plot space, 1 m inter-block space. Three seedlings (35 days) were transplanted per hill at the spacings of 20 cm × 20 cm on 26th August 2021.

Treatments design was as follows:

Treatments	Particulars
T ₁	Control (No fertilizer)
T ₂	Chemical fertilizer (CF)/ Recommended dose (RD)
T ₃	Biochar + RD
T ₄	DBP Compost + RD
T ₅	DBP Compost + Biochar + RD

Biochar was produced by an anaerobic pyrolysis process at 400 °C for 2–2.5hr. Fertilizer was applied as per BRRI, 1991 recommendation i.e. 90 kg N, 8.5 kg P₂O₅, 50 kg K₂O, 4 kg S, and 1 kg Zn per ha. The sources of N, P, K, S, and Zn were urea, triple super phosphate, muriate of potash, gypsum, and zinc sulfate, respectively. Total chemical fertilizers (kg/ha) used for the trial were 195.65 urea, 42.5 TSP, 100 MoP, 24.50 gypsum, and 2.78 zinc sulfate. Organic materials were applied at a rate of 2.5tonha⁻¹, and the remaining nutrients were applied according to the IPNS approach based on AEZ number and fertilizer recommendation guide (FRG, 2018). For T₅ plots, 1.25 tonha⁻¹ compost, and 1.25 tonha⁻¹ biochar were used, and the remaining nutrients were supplied from chemical fertilizer according to the IPNS approach like other plots.

A non-selective herbicide named Glyphosate (Round up®) was sprayed over the field at a rate of 1.85 kg ha⁻¹ before 3 days of final land preparation. In addition, Pretilachlor (Superhit®, pre-emergence herbicide) was used at a rate of 450 g ha⁻¹ at 5 days after the transplanting of rice seedlings. Brifer 5G and Cidial 5G (ACI Bangladesh Ltd.) were applied as required to control rice insects. Growth and yield parameters (plant height, tiller no/hill, biomass yield (t/ha), grain yield (t/ha), weight of 1000 seeds) were recorded. All the recorded data were tabulated in MS. Excel 2010. One-way analysis of Variance (ANOVA) was performed for the test of significance. The Duncan's Multiple Range Test (DMRT) was performed for mean comparison.

RESULTS AND DISCUSSION

Nutrient composition of DBP compost

The pH value of the final DBP compost was found basic (8.30), which is suitable for the acidic soil of Bangladesh (Table 1). Moreover, organic carbon content, total nitrogen, and carbon-nitrogen ratio were found at 21.89%, 1.83%, and 13.68, respectively. Similarly, total phosphorus, potassium, and sulfur content were recorded as 0.29%, 1.57%, and 0.33%, respectively.

Performance of DBP compost in Aman rice production

Growth parameters and yield parameters

Plant height among all treatments was found highly significant ($p < 0.01$) (Table 2). The tallest plant height was recorded in T₄ (103.70 cm), followed by T₅, T₃, T₂, and the shortest height was observed in T₁ (83.90 cm). Plant heights of T₄ and T₅ were found to be non-significant.

Table 2 and Table 3 demonstrated that, except for panicle length and number of grain/panicle, all yield parameters were highly significant ($p < 0.01$). The number of tillers/hill ranged from 10.48 to 14.78 among all treatments. The maximum tiller no/hill was observed in T₅ (14.78), followed by T₄, T₃, T₂, and the minimum was recorded in T₁ (10.48). Similarly, a statistically significant ($p < 0.01$) result was observed in the case of biomass yield and straw yield (Table 3). The highest biomass yield was recorded in T₅ (18.94t/ha), and the lowest was in T₁ (10.76t/ha). However, a statistically non-significant result was observed between T₄ and T₅. Similarly, the highest straw yield was observed in T₅ (12.63 t/ha), and the lowest yield was observed in T₁ (6.98 t/ha). Straw yield in the case of T₅, T₄, and T₃ was also observed to be statistically similar.

In the same manner, panicle weight/hill and grain weight/hill were also found significant ($p < 0.01$) among the treatments (Table 2). In T_5 , the maximum (27.82 gm) panicle weight/hill was observed, followed by T_2 , T_4 , T_3 , and the minimum was recorded in T_1 (15.10 gm/hill). Likewise, grain weight/hill (Table 3) was found to be the highest in T_5 (25.45 gm), followed by T_2 , T_4 , T_3 , and the lowest value was observed in T_1 (13.84 gm).

Grain yield/ha, test weight of seed, percent of filled grain, and percent of unfilled grain were also highly significant ($p < 0.01$) among treatments. Test weight of seed was the highest in T_5 (23.88 gm), followed by T_4 , T_3 , T_1 , and the minimum test weight was observed in T_2 (20.69 gm) (Table 3). In addition to that, the percentage of grain-filled seed was recorded the maximum (95 %) in T_5 and T_4 , and the minimum was observed in T_1 (79 %) (Table 3).

Table 1. Nutrient composition of DBP compost in Bangladesh Agricultural University, 2020/21

Particulars	Moisture %	pH	OC (%)	T. N (%)	C/N ratio	P (%)	K (%)	S (%)
DBP Compost	66.47	8.30	21.89	1.83	13.68	0.29	1.57	0.33

TN: Total Nitrogen, P: Phosphorus; K: Potassium; S: Sulfur; OC: Organic Carbon

Table 2. Growth and yield parameters of Aman rice in Bangladesh Agricultural University, 2020/21

Treatments	Tiller no/hill	Plant height (cm)	Biomass yield (t)/ha	Grain yield (t)/ha	Straw yield (t)/ha
	Mean \pm SEM	Mean \pm SEM	Mean \pm SEM	Mean \pm SEM	Mean \pm SEM
T_1	10.48 ^b \pm 0.80	83.90 ^c \pm 1.95	10.76 ^c \pm 0.98	3.58 ^c \pm 0.37	6.98 ^c \pm 0.59
T_2	12.75 ^a \pm 0.58	95.75 ^b \pm 0.90	16.05 ^b \pm 0.79	5.16 ^b \pm 0.12	10.68 ^b \pm 0.68
T_3	12.86 ^a \pm 0.37	99.00 ^b \pm 0.34	16.32 ^b \pm 0.64	5.25 ^{ab} \pm 0.28	10.94 ^{ab} \pm 0.44
T_4	14.25 ^a \pm 0.89	103.70 ^a \pm 1.27	17.13 ^{ab} \pm 1.29	5.50 ^{ab} \pm 0.34	11.33 ^{ab} \pm 0.92
T_5	14.78 ^a \pm 1.00	103.00 ^a \pm 0.32	18.94 ^a \pm 0.27	6.03 ^a \pm 0.10	12.63 ^a \pm 0.17
P value	0.01	0.000	0.000	0.000	0.000
LS	*	**	**	**	**
CV%	10.63	2.57	10.68	10.85	10.38
LSD _(0.05)	2.13	3.85	2.61	0.85	1.82

T_1 : Control (No fertilizer), T_2 : Chemical fertilizer (CF)/ Recommended dose (RD), T_3 : Biochar + RD, T_4 : DBP Compost + RD, T_5 : DBP Compost + Biochar + RD, LS: Level of significance, SEM: Standard Error of Mean

Table 3. Yield parameters of Aman rice in Bangladesh Agricultural University, 2020/21

Treatments	Panicle length (cm)		No of grain/panicle		Panicle weight (gm)/hill		Grain Weight (gm)/hill		Test weight of seed (gm)		Grain unfilled seeds (%)		Grain filled seeds (%)	
	Mean ± SEM	SEM	Mean ± SEM	SEM	Mean ± SEM	SEM	Mean ± SEM	SEM	Mean ± SEM	SEM	Mean ± SEM	SEM	Mean ± SEM	SEM
T ₁	21.44 ± 0.38		152.58 ± 1.91		15.10 ^d ± 0.24		13.84 ^d ± 0.49		21.51 ^c ± 0.09		21.00 ^a ± 1.08		79.00 ^c ± 1.08	
T ₂	23.84 ± 0.88		153.93 ± 1.69		26.18 ^b ± 0.90		23.79 ^{ab} ± 0.40		20.69 ^d ± 0.02		15.00 ^b ± 0.41		85.00 ^b ± 0.41	
T ₃	23.14 ± 0.55		149.40 ± 1.18		21.21 ^c ± 0.25		18.40 ^c ± 0.59		23.19 ^b ± 0.20		15.00 ^b ± 0.41		85.00 ^b ± 0.41	
T ₄	24.00 ± 0.62		160.28 ± 1.24		25.13 ^b ± 0.74		23.28 ^b ± 0.67		23.44 ^b ± 0.14		7.00 ^c ± 0.71		93.00 ^a ± 0.71	
T ₅	23.59 ± 1.43		155.08 ± 1.16		27.82 ^a ± 0.16		25.45 ^a ± 0.57		23.88 ^a ± 0.12		7.00 ^c ± 0.58		93.00 ^a ± 0.58	
P value	0.261		0.258		0.000		0.000		0.000		0.000		0.000	
LS	NS		NS		**		**		**		**		**	
CV%	8.00		4.70		4.30		5.84		1.21		10.22		1.53	
LSD _(0.05)	2.60		11.97		1.53		1.89		0.42		2.05		2.05	

T₁: Control (No fertilizer), T₂: Chemical fertilizer (CF)/ Recommended dose (RD), T₃: Biochar + RD, T₄: DBP Compost + RD, T₅: DBP Compost + Biochar + RD, LS: Level of significance, SEM: Standard Error of Mean

IMO mixed DBP compost contains millions of microbes that contribute to beneficial soil effects such as nitrogen fixation, mineralization, humus formation, disease suppression, and decomposition (Sanchez et al., 2018). Indigenous microorganisms such as photosynthetic bacteria, lactic acid bacteria, and fermenting fungi (*Aspergillus*, *Penicillium*, *Trichoderma*) promote plant growth and development, increase rapid decomposition of organic matter, suppress odors, and prevent infestation of harmful insects and maggots (Sanchez et al., 2018). Sakimin et al. (2017) reported that there was a significant increase in plant height with increasing DAP of rice treated with IMOs. This suggests that the application of IMOs enhances soil fertility and nutrient uptake. Samin (2011) reported that plants and microorganisms live symbiotically in a natural environment, and beneficial microorganisms such as IMOs and other local formulations produce nutrients, hormones, and antibiotics in small quantities, and plants absorb them. It is believed that IMO inoculants could improve soil structure and increase nutrient uptake by the crop and ultimately growth and yield (Prell, 2010). Phua et al. (2011) particularly studied the isolated indigenous microorganisms that may enhance plant growth through N₂ fixation using the 15 N isotopic tracer techniques, solubilize insoluble inorganic phosphate compounds or hydrolyze organic phosphate to inorganic P, or stimulate plant growth through hormonal actions such as IAA production. DBP compost 'organic fertilizer' is one of the critical elements of organic and sustainable agricultural development. Positive and significant increased rice yield by using organic fertilizer, which supports less requirement of chemical fertilizer (Salam et al., 2021). An enhancement in growth, yield, and yield contributing characteristics of wheat and rice in the wheat-rice cropping systems has also been reported with the integrated use of IMOs, chemical fertilizer and cow dung or poultry biogas slurry (Haque et al., 2018) due to higher plant uptake of total N, P, K, and S.

The application of biochar-amended organic fertilizer significantly increased the yield of rice crops grown on the tropical riparian wetland (Lakitan et al., 2018). Haider et al. (2017) found that the application of biochar with chicken manure increased soil carbon, availability of ammonium (NH₄⁺), mineralizable nitrogen, and extractable phosphorus. Agegnehu et al. (2016) reported that the application of biochar significantly increased barley yield. Higher yield at a higher rate of biochar application was very significantly related to the number of tillers per hill, productive tillers per hill, number of grains per panicle, percentage of filled grain, and weight of 1,000 grains; but was not related to panicle length (Liu et al., 2016). Liang et al. (2016) reported that finer particle sizes of biochar increased soil enzyme activity. Zhang et al. (2013) concluded that the rice yield with biochar addition (20 and 40 t/ha) was 15.53% and 24.43% higher than that of non-biochar addition paddy fields under water-saving irrigation. The addition of biochar promoted the growth of tillers and plant height, improved the filled grain number, productive panicle number, and seed setting rate, thus affecting rice yield. Higher biomass yield at a higher rate of compost application was very significantly related to grain yield and weight of 1,000 grains (Liu et al., 2016).

The continuous and excessive use of chemical fertilizers in rice cultivation has contributed to the decline of soil organic matter, nutrient imbalance, and reduced sustainability of agricultural production systems (Urmi et al., 2022). The integration of organic amendments such as biochar and compost with recommended fertilizer doses has been proposed as an effective strategy to improve soil fertility, nutrient availability, and crop productivity while reducing reliance on synthetic fertilizers (Rahman et al., 2022). Biochar and compost can enhance soil physical, chemical, and biological properties through increased nutrient retention, improved water-holding capacity, and stimulation of beneficial microbial activity (Hassan et al., 2024). Previous studies have also reported that integrated nutrient management improves rice yield, nutrient use efficiency, and soil carbon sequestration compared with the sole application of chemical fertilizers (Rahman et al., 2022; Urmi et al., 2022).

Correlation among growth and yield attributes

Fig. 1 predicted that each additional ton of biomass yield is associated with an additional 0.297 tons of grain yield. And, 96.6% of the variation in grain yield (ton) is explained by the variation in biomass yield (ton). Similarly, Fig. 2 demonstrated that each additional ton of biomass yield is associated with an additional 0.694 tons of straw yield. And, 99.8% of the variation in straw yield is explained by the variation in biomass yield. In the same manner, Fig. 3 depicted that each additional centimeter of plant height is associated with an additional 0.112 cm of panicle length. And, 23.00% of the variation in panicle length (cm) is explained by the variation in plant height (cm). Furthermore, these three figures elucidated that there was a high positive correlation ($R=0.983$; $R=0.998$) between biomass yield (t/ha) and grain yield (t/ha); biomass yield (t/ha) and straw yield (t/ha), respectively. However, a low positive correlation ($R=0.479$) was observed between plant height (cm) and panicle length (cm).

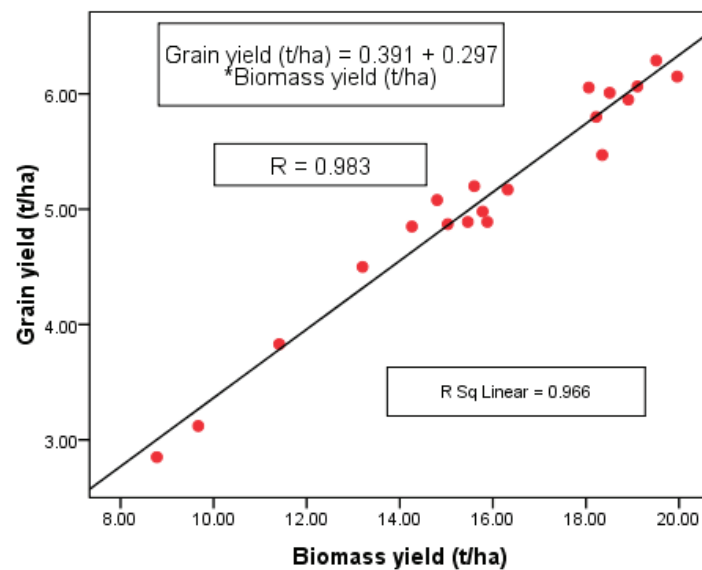


Fig. 1. Correlation between Biomass yield (t/ha) and Grain yield (t/ha)

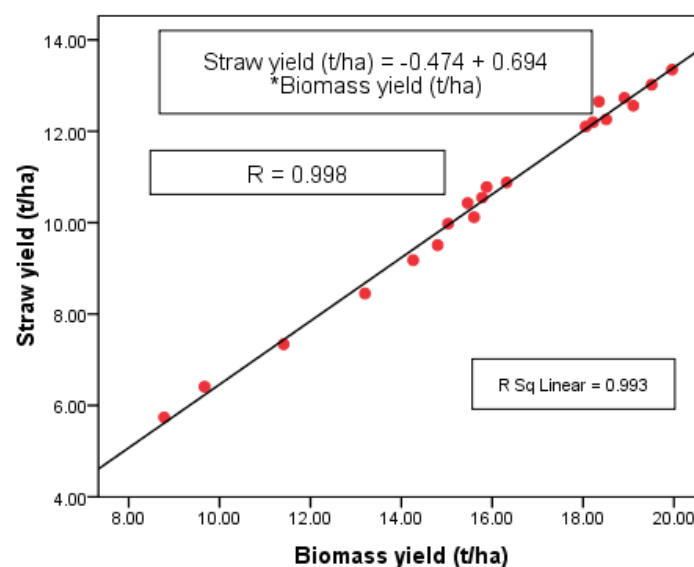


Fig. 2. Correlation between Biomass yield (t/ha) and Straw yield (t/ha)

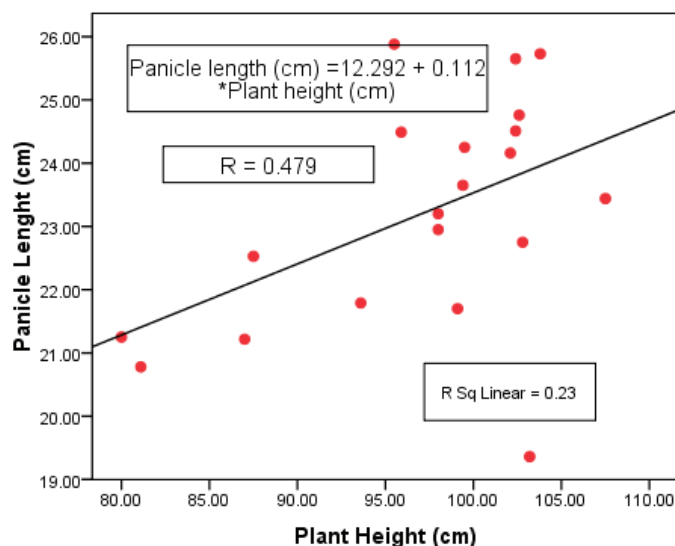


Fig. 3. Correlation between Plant height (cm) and Panicle length (cm)

Dahal *et al.* (2021) found a positive correlation between the biomass yield of rice and grain yield. A similar result was obtained in the case of plant height (cm) and panicle length (cm). Dahal *et al.* (2021) also found that 53% of the variation in grain yield (ton) in rice is explained by the variation in biomass yield (ton).

CONCLUSION

The integrated application of DBP compost, biochar, and the recommended dose of chemical fertilizer showed superior performance in improving the growth, yield, and yield-contributing characteristics of Aman rice compared with the other treatments. The results suggest that combining organic amendments with chemical fertilizers can enhance crop productivity and support more sustainable nutrient management practices. However, further multi-location and multi-season studies, along with a comprehensive economic analysis, are needed to verify the consistency, feasibility, and cost-effectiveness of this approach before making a broad recommendation for farmers.

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AUTHOR CONTRIBUTIONS

HRD: Conceptualization, Investigation, Formal analysis, Writing – original draft; **AAK:** Data curation, Writing – review & editing, Supervision; **ZG:** Data curation, Writing – review & editing, Supervision; **MMR:** Data curation, Writing – review & editing, Supervision; **RA:** Data curation, Writing – review & editing, Supervision; **RIK:** Data curation, Writing – review & editing, Supervision.

CONFLICT OF INTEREST

The authors agree in not having any conflict of interest regarding the published material. All the authors had gone through the document before the submission to the Journal of Agriculture and Forestry University.

ETHICAL APPROVAL AND PERMITS

Not applicable.

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