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Brown Manuring, an Effective Technique for Yield Sustainability and Weed Management of Cereal Crops: A Review

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ABSTRACT

The efficient nutrient management is essential to achieve crop yield sustainability. Integration of all possible sources of nutrients can only fulfill the requirement of crops and wherein yield sustainability can be ascertained. Organic manures can play in important role in this direction. But these manures are bulky in nature and low in nutrient content, hence the substitution is highly required. Green manure, another possible option of providing nutrients to crops from organic sources, but it has got some limitations as it is practiced in mainly rice crop that requires a period of about 45-60 days from seeding to decomposition with proper temperature and optimum moisture conditions after incorporation. The viable option left behind that is brown manuring as a tool for integrated nutrient management. Brown manuring is capable of supplying all nutrients to the crops which is also considered beneficial for weed management as well as improving soil properties.

Keywords: Brown manuring, cereals, nutrient and weed management, soil health, yield sustainability

Rice has largest contribution to sustained self-sufficiency in food grain production to feed ever increasing population of the country. Development of input-responsive varietal introduction capable of achieving high yield potential particularly under irrigated ecology is responsible to this attainment (Zaman, 2012). The area under total rice growing eco-system of the country is 44.0 mha, amongst which upland rice shares only 7.0 mha and lowland covers 17.0 mha. The productivity of upland and lowland rice are 0.65 and 1.9 t/ha, respectively. In West Bengal total rice growing area is 5.6 mha, amongst which up and lowland rice are having 1.01 and 1.85 mha, with the productivity levels of 0.95 and 2.01 t/ha, respectively (Zaman, 2016). Fertilizers have contributed substantially to the spectacular increase in crop production. However, application of inorganic fertilizers alone in large quantities over a longer period of time results in imbalance in the supply of other nutrients. The combined use of organic manures and inorganic fertilizers help in maintaining yield stability through correction of marginal deficiencies of secondary and micronutrients, enhancing efficiency of applied nutrients and providing favourable soil physical conditions. N-use efficiency from inorganic sources varies from 18-40 per cent in rice soils, because applied N is rapidly lost from the soil by ammonia volatilization and denitrification. Urea is the principal nitrogenous fertilizer in rice-growing Asian countries. Large loss of N from urea necessitates an innovative application technique for increasing the N-use efficiency in rice farming. Application of urea in combination with organic material (farm yard manures, composts and others), use of slow release fertilizers at source, mud ball applications of N-fertilizers are helpful for minimizing N loss and increasing N-use efficiency. India has enough potential of organic wastes which can be converted into composts and organic manures and used in crop fields. But the huge quantity of organic waste is not properly and scientifically converted into composts and lost by various means. Besides, carrying cost of the low-value bulky organic manures is also expensive. The option like green manuring may be tried to add organic manure in soil, it needs some time to decompose after incorporation into the soil. Moreover, the decomposition process in green manuring needs certain temperature and sufficient moisture in the soil which may not be congenial throughout the year in different parts of the country. Therefore brown manuring can be a viable option which is free from these limitations.

BROWN MANURING

Brown manuring is simply a 'no-till' version of green manuring, using an herbicide to desiccate the crop before flowering instead of using cultivation. According to this technique, *Sesbania* or other green manure crops are grown in standing cereal crops and killing them with the help of herbicide for manuring where the plant residues are left standing in the field along with main crop without incorporation/in-situ ploughing until its residue decomposes itself in the soil aiming to add organic manure beside weed suppression by its shade effect.. The post-emergence herbicide spray on green manure leaves resulting in loss of chlorophyll in leaves showing brown in colour is referred to as brown manuring (Tanwar *et al.,* 2010). Generally, brown manuring practice is introduced in the fields where *Sesbania* spp @ 20 kgha^{-1} is broadcast three days after rice sowing and allowed to grow for 30 days and was dried by spraying 2,4-D ethyle-easter which supplied upto 35 kgha^{-1} N, dry matter, control of broad leaf weeds, higher yield by 4 -5 q ha^{-1} due to addition of organic matter in low fertile soils. This may also be a preferred option on lighter soils prone to erosion and reduce weeds (Sharma, 2014; Singh, 2014). Brown manuring not only adds organic matter content but also improves the physico-chemical and biological properties of the soil. Since not much works have been done in this field, this article focuses to address the potential of brown manuring in maximizing yield of cereals and controlling weeds based on a reasoned analysis of the literature on this subject published recently along with a highlight on the benefits of brown manuring.

Effect on yield, soil health and weed management

Brown manuring helps smothering weeds, conserving moisture and adding about 15kg N ha^{-1} without adding much on cost of production (Gaire *et al.,* 2013). A lower broad-leaved weed density and dry weight were observed with *Sesbania* spp. and other brown manuring species than the surface mulch. Intercropping of brown manuring crops with rice reduced weed densities by about 40-50 per cent (Rehman *et al.,* 2007). Singh *et al*. (2007) reported that application of wheat residue mulch at 4t ha^{-1} and *Sesbania* intercropping for 30 days were equally effective in controlling weeds in dry-seeded rice.

Sarangi *et al.* (2016) conducted an experiment to study effects of replacing 25% of nitrogenous fertilizer by brown manuring in direct seeded rice and observed that the plant height (1.57%), effective tiller number (9.09%), organic carbon content (13.04%) and grain yield (7.91%) were increased in the brown manuring plots as compared to farmers practice. The biomass incorporated in the field (133%) was significantly improved in the brown manuring fields indicating better soil health. The benefit: cost ratio was 7.79 that wasmore in the brown manuring plots than that of farmers practice. Sarangi*et al* (2016) concluded that use of nitrogenous fertilizer can be reduced up to 25 per cent in the farmers' field by brown manuring without affecting the economical attributes and saving the precious soil health from the study. Besides, Sharma *et al.* (2017) noted significantly higher actinomycetes count with brown manuring in Basmati rice cultivated under the method of system of rice intensification. Increasing soil organic matter through brown manure or addition of plant or animal organic matter from external sources is also important in decreasing bulk density of the soil and acting as a buffer preventing or lessening the transmission of compaction to subsoil from external loads acting on the topsoil (Hamza and Anderson, 2005).

The sustainability of rice–wheat cropping system (RWCS) is threatened by increasing labor, water, and energy crises. Conservation RWCSs offers an eco-friendly alternate option. In an experiment Nawaz *et al*. (2017) studied to evaluate the impact of *Sesbania* brown manuring in direct-seeded aerobic rice (DSAR) and of rice residue mulch in no-tilled wheat (NTW) on soil health, weed dynamics and system productivity. They observed that *Sesbania* brown manuring in direct-seeded rice decreased the weed density and dry biomass 41–56 and 62–75%, respectively, than the sole direct-seeded rice crop. At rice harvest, better soil health, in terms of total nitrogen (N), soil organic carbon, soil microbial biomass carbon, and soil microbial biomass nitrogen, was noted with direct seeded aerobic rice (DSAR)+*Sesbania* brown manuring–NTW. NTW grown after DSAR+*Sesbania* brown manuring produced more grain yield than puddle transplanted rice – no tilled wheat system and puddle transplanted rice – plough-tilled wheat systems. The findings suggested beneficial effects of brown manuring of *Sesbania* in rice – wheat cropping system.

Maiti and Mukherjee (2011) conducted a field study to work out integrated weed management practices with its economics in dry direct seeded *kharif* rice. Amongst the weed flora, emergence of grasses like *Cynodon dactylon* and *Echinochloa colona*, sedges like *Cyperus rotundus, Cyperus iria* and *Fimbristylis miliacea* and broad-leaved weeds like *Ludwigia parviflora, Ageratum conyzoides, Spilanthes paniculata, Eclipta alba* and *Enhydra fluctuans* were recorded during experimentation. Amongst the integrated weed management practices, butachlor 1.5 kgha^{-1} as pre-plant surface application followed by practices of brown manuring and post-emergence application of 2, 4-D 0.50 kgha^{-1} at 40 days after sowing recorded highest grain yield (3.0 and 3.88 t ha^{-1}), highest net returns and benefit: cost ratio. The grain yield was statistically at par with the grain yield (3.14 and 3.98 t ha^{-1}) obtained from season long weed-free condition. There has been considerable improvement in nutrient use efficiency due to adoption of weed control practices coupled with nitrogen management and among the integrated weed management practices highest nutrient use efficiency of N (50.00 and 64.67 kg grain yield per kg nutrient applied), P (229.36 and 296.64 kg grain yield per kg nutrient applied) and K (90.36 and 116.87 kg grain yield per kg nutrient applied) were highest with butachlor 1.5 kgha^{-1} + brown manuring + 2, 4-D 0.5 kgha^{-1} in both the years.

Aslam *et al.* (2008) found that paddy yield direct seeding and brown manuring (4.23 t ha^{-1}) was significantly higher than direct seeding without brown manuring(3.36 t ha^{-1}). In a review, Gill and Walia (2014) narrated that Grain yield of direct seeded rice with brown manuring *Sesbania* was statistically at par with conventional transplanting of rice. Sharma *et al*. (2008) found that direct seeding with *Sesbania* spp co-culture as a brown manuring yielded (3.65 t ha^{-1}) which was at par, compared to conventional transplanting (3.69 t ha^{-1}) and significantly higher than direct seeding without brown manuring (3.24 t ha^{-1}) and also it saved 43.6 per cent water over conventional transplanting. In integrated weed-management practices, butachlor @ 1.5 kgha^{-1} as pre-plant surface application + brown manuring with *Sesbania rostrata*+ 2,4-D @ 0.50 kg ha^{-1} recorded the highest grain yield (3.88 t ha^{-1}), which was significantly on a par with that obtained from season-long weed-free situation (3.98 t ha^{-1}). The highest net returns (INR 19,029 ha^{-1}) and benefit: cost ratio (1.19) was also recorded in same treatment (Kumar and Mukherjee, 2008).

Singh *et al*. (2009) recorded that rice yield in direct seeding + brown manuring (3.50 t ha^{-1}) were at par, compared to conventional transplanting (3.56 t ha^{-1}) but, significantly higher than direct seeding without brown manuring (3.22 t ha^{-1}) and also it saved 39.4 per cent water over transplanting. In Haryana, Singh *et al*. (2008) conducted an experiment and results revealed that *Sesbania* sown along with rice gave maximum yield (5.54 t ha^{-1}) and it was on par with *sesbania* sown at 5 days of rice (5.41 t ha^{-1}) and significantly higher than sole crop of rice (4.70 t ha^{-1}). The results revealed that maximum weed density was observed in sole crop of rice (68 weeds m^{-2}) as compared to only (15 weeds m^{-2}) in *Sesbania* spps own along with rice. Singh *et al*. (2008) found that direct seeding with *Sesbania* spp co-culture as a brown manuring yielded (4.51 t ha^{-1}) significantly at par with conventional transplanting (4.70 t ha^{-1}) and significantly higher than direct seeding without brown manuring (4.00 t ha^{-1}). They also found that maximum weed density was observed in direct seeding without brown manuring (40 weeds m^{-2}) whereas, direct seeding with brown manuring (15 weeds m^{-2}) and conventional transplanting (16 weeds m^{-2}) gave at par weed density.

Further, brown manuring (broadcasting of *Sesbania* along with rice seeding and killing *Sesbania* by spraying 2, 4-D around 30 days after seeding) or mulching reduced the weed density by 37-42 per cent compared to the rice crop without brown manuring and mulching (Singh *et al.* 2009). Application of butachlor and brown manuring was

Table 1: Effect of brown manuring on weed density, yield and economics of maize (Ramachandran *et al.*, 2012)

Treatment	Density of weeds at 60 DAS (no.m^{-2}) Grasses Sedges Broad leaved Total	Yield (t ha^{-1}) Grain Stover	B:C ratio
Mechanical weeding by hand hoe at 20 and 35 DAS	7.50 6.66 5.66 19.82	5.67 8.51	2.43
PE Alachlor 1kg ai ha^{-1} + mechanical weeding at 35 DAS	7.16 6.16 5.49 18.48	5.75 8.63	2.70
Intercropping Dhanicha and in situ incorporation at 35 DAS	9.66 8.00 8.00 25.66	4.56 6.85	2.16
Brown manuring	9.26 7.66 7.66 24.15	4.61 6.92	2.37
PE Alachlor 1kg ai ha^{-1} + Intercropping Dhanicha and in situ incorporation at 35 DAS	5.66 4.20 4.20 14.19	6.38 10.20	2.97
PE Alachlor 1kg ai ha^{-1} + brown manuring	4.16 3.20 3.16 10.52	7.23 11.56	3.61
Un-weeded check	32.83 32.16 36.66 101.65	3.19 4.80	1.71
LSD (P=0.05)	0.031 0.058 0.062 0.054	0.31 0.31	—

PE= Pre-emergence; DAS= Days after sowing

able to reduce weed pressure, as brown manuring acted as a cover crop in suppressing weed growth effectively in rice field (Kumar and Mukherjee, 2011; Dubey, 2014). Drum seeding alone or drum seeding + *dhaincha* brown manure (Prabhakaran and Chinnusamy, 2006) was found effective in reducing density and dry matter accumulation of weeds and increased yield of rice. Seema *et al.* (2015) noted beneficial effect of brown manuring in yield and weed management in aerobic rice and soil enrichment with nutrients. Moreover, Yadav *et al.* (2014) observed brown manuring with *Sesbania* and cowpea had positive responses in lowering weed population and increasing yield in direct seeded rice. The brown leaves of *Sesbania* spp after the herbicide application would serve the purpose of mulch and hence smother the weed flora associated in rice (Mahajan *et al*., 2009).

Though there was very less work on brown manuring, the most of the works are confined to only rice crop. However, brown manuring in maize is also beneficial. The weeds account for 40% yield loss and even more than 70% yield loss may be cause under uncontrolled weed growth condition in maize. However, in the current scenario of agriculture, evolving eco-friendly approach of weed control is more advisable so as to protect the natural resources such as soil flora and fauna including human being and animals in a holistic manner. In this context, an advanced weed management strategy which has emerged in India is brown manuring. Ramachandran *et al.* (2012) revealed that brown manuring helped in suppressing the weeds upto 50% of total weed population on the account of the shade effect of killed manure crop till 45 days after sowing which is considered as the critical period of crop weed competition in *rabi* maize. They also observed significantly positive impact of brown manuring on productivity and net return of maize (Table 1).

CONCLUSION

Hence, the reviews of the above cited literatures revealed that brown manuring the best option for applying for growing crops to increase productivity and maintaining sustainability which are also cost effective and eco-friendly restoring soil health in present day agriculture.

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