

Brown manuring for improved crop growth, yield and energetics of wet seeded-rice (*Oryza sativa*) in the coastal deltaic eco-system

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Received: November 2023; Revised accepted: February 2024

ABSTRACT

A field experiment was conducted during October 2020–January 2021 at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry to study the effect of different seeding rates of [*Sesbania bispinosa* (Jacq.) W. Wight] (*Sesbania*) in rice co-culture along with suitable post-emergence herbicides for brown manuring on crop productivity and energetics in wet seeded rice (*Oryza sativa* L.). The experiment consisted of 10 treatments, viz. T₁, *Sesbania* seeding rate for brown manuring (BM) @15 kg/ha with 2,4-D 0.5 kg/ha; T₂, *Sesbania* seeding rate for BM @20 kg/ha with 2,4-D 0.5 kg/ha; T₃, *Sesbania* seeding rate for BM @25 kg/ha with 2,4-D 0.5 kg/ha; T₄, *Sesbania* seeding rate for BM @15 kg/ha with bispyribac sodium 25 g/ha; T₅, *Sesbania* seeding rate for BM @20 kg/ha with bispyribac sodium 25 g/ha; T₆, *Sesbania* seeding rate for BM @25 kg/ha with bispyribac sodium 25 g/ha; T₇, rice alone with 2,4-D 0.5 kg/ha; T₈, rice alone with bispyribac sodium 25 g/ha; T₉, hand weeding twice at 20 and 40 DAS (days after sowing); T₁₀, unweeded control in a randomized block design (RBD) with three replications. *Sesbania* seeding rate for brown manuring (BM) @25 kg/ha + 2,4-D 0.5 kg/ha recorded significantly lower total weed density (73.3 no./m²) and weed dry weight (37.0 g/m²). Significantly higher crop growth rate (CGR) (528.2 g/m²/day), plant height (132.8 cm) and rice yield (4823 kg/ha) were observed under *Sesbania* seeding rate for BM @25 kg/ha + 2,4-D 0.5 kg/ha which was comparable with *Sesbania* seeding rate for BM @25 kg/ha + bispyribac sodium 25 g/ha but superior to treatments without BM and eventually resulted in higher energy productivity (0.59 to 0.60 kg/MJ), energy profitability (7.74 to 7.77 kg/MJ) and the energy use efficiency (8.74 to 8.77). Thus, *Sesbania* seeding rate @25 kg/ha along with spraying either 2,4-D 0.5 kg/ha or bispyribac sodium 25 g/ha for brown manuring could be recommended in wet seeded rice.

Key words: Brown manuring, Energetics, Herbicides, Weed interference, Wet seeded rice

Rice (*Oryza sativa* L.) is the most important staple food crop generally cultivated by transplanting method in India as well as in the world. Labour shortage and water crises at critical period along with hike in labour wages (Vijayakumar *et al.*, 2019), threaten the transplanted rice production which is being replaced by the direct seeding using pre-germinated rice seeds in puddled condition in many Asian countries. However, weed menace is a big constraint in the direct seeded rice ecosystem. Even though the use of herbicides offers a great scope for timely and effective weed control, the continuous use of herbicides leads to environmental problems and residual toxicity, besides causing shift in weed flora. This necessitates the use of cultural approaches during critical periods of weed inter-

ference (Saravanane and Chellamuthu, 2016) to enhance crop-competitiveness, which do not cause any deleterious effect to soil and the succeeding crops.

Basically, brown manuring (BM), is a “no-till” version of green manuring, using a herbicide to desiccate the green manure plant before flowering (Das *et al.*, 2019). In brown manuring, green manure crops are grown along with cereal crops followed by application of a selective post-emergence herbicide at appropriate time, which will result in the killing of only green manure crops due to knock down effect (Behera *et al.*, 2018). [*Sesbania bispinosa* (Jacq.) W. Wight] (*Sesbania*) is considered as the most suitable *in-situ* green manure in lowland rice (Singh and Gangaiah, 2012). However, there are no studies involving seeding rate of *Sesbania* and suitable post-emergence herbicides for brown manuring in wet seeded rice crop in the Cauvery deltaic ecosystem, which is considered to be one of South India's rice bowls supports 4.4 million people. Keeping this in view, a systematic effort was made to study the effect of seeding rate of *Sesbania* and suitable post-emergence

Based on a part of M.Sc. Thesis of the first author submitted to Pondicherry University, Kalapet, Puducherry in 2021 (unpublished)

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herbicides for brown manuring on crop growth, productivity and energetics in wet seeded rice at coastal Cauvery deltaic ecosystem of Karaikal, Puducherry (Union Territory).

A field experiment was conducted during October 2020–January 2021 at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry (Union Territory). The soil was sandy clay loam with a pH 6.04, low in available N (198.9 kg/ha), medium in available P (23.5 kg/ha) and available K (244.6 kg/ha). The experiment was conducted with 10 treatments, viz. T₁, *Sesbania* seeding rate for brown manuring (BM) @15 kg/ha with 2,4-D 0.5 kg/ha; T₂, *Sesbania* seeding rate for BM @20 kg/ha with 2,4-D 0.5 kg/ha; T₃, *Sesbania* seeding rate for BM @25 kg/ha with 2,4-D 0.5 kg/ha; T₄, *Sesbania* seeding rate for BM @15 kg/ha with bispyribac sodium 25 g/ha; T₅, *Sesbania* seeding rate for BM @20 kg/ha with bispyribac sodium 25 g/ha; T₆, *Sesbania* seeding rate for BM @25 kg/ha with bispyribac sodium 25 g/ha; T₇, rice alone with 2,4-D 0.5 kg/ha; T₈, rice alone with bispyribac sodium 25 g/ha; T₉, hand weeding twice at 20 and 40 DAS (days after sowing); T₁₀, unweeded control, replicated thrice in a randomized block design (RBD). Pre-germinated seeds of rice cultivar Improved White Ponni (60 kg/ha) were sown with 10 cm spacing between and *Sesbania* seeds (as per treatments) were evenly broadcasted on the same day of rice sowing. The entire quantity of phosphorus (P) was applied as basal in the form of single super phosphate (SSP). Recommended dose of N and K were applied in four equal splits at 21 DAS, at active tillering, panicle initiation and heading stages in the form of urea and muriate of potash (MOP), respectively. Two herbicides, viz. 2,4-D amine salt 58% SL and bispyribac sodium 10% SC were used for knocked down *Sesbania* to brown manuring as post-emergence at 28 DAS. Recommended quantity of herbicides was diluted in water @500 litre/ha and applied in respective plots using a knapsack sprayer fitted with flood jet nozzle. Data on weed density and dry matter accumulation were recorded at 60 DAS using quadrates of size 0.5 m × 0.5 m (Saravanane and Chellamuthu, 2016) placed at two random places in each plot. The grain yield from the net plot was measured and expressed in kg/ha at 14% moisture content. The energy indices pertaining to various treatments were calculated using the energy equivalents of various inputs, operations and various energy sources (Vijayakumar *et al.*, 2019). The data on weed density and dry weight were transformed to square root transformation ($\sqrt{x+0.5}$) to normalize their distribution before analysis. These experimental data were then subjected to statistical scrutiny by using the standard method of analysis of variance.

It is evident from the present study that brown manuring resulted in decrease of total weed density and dry

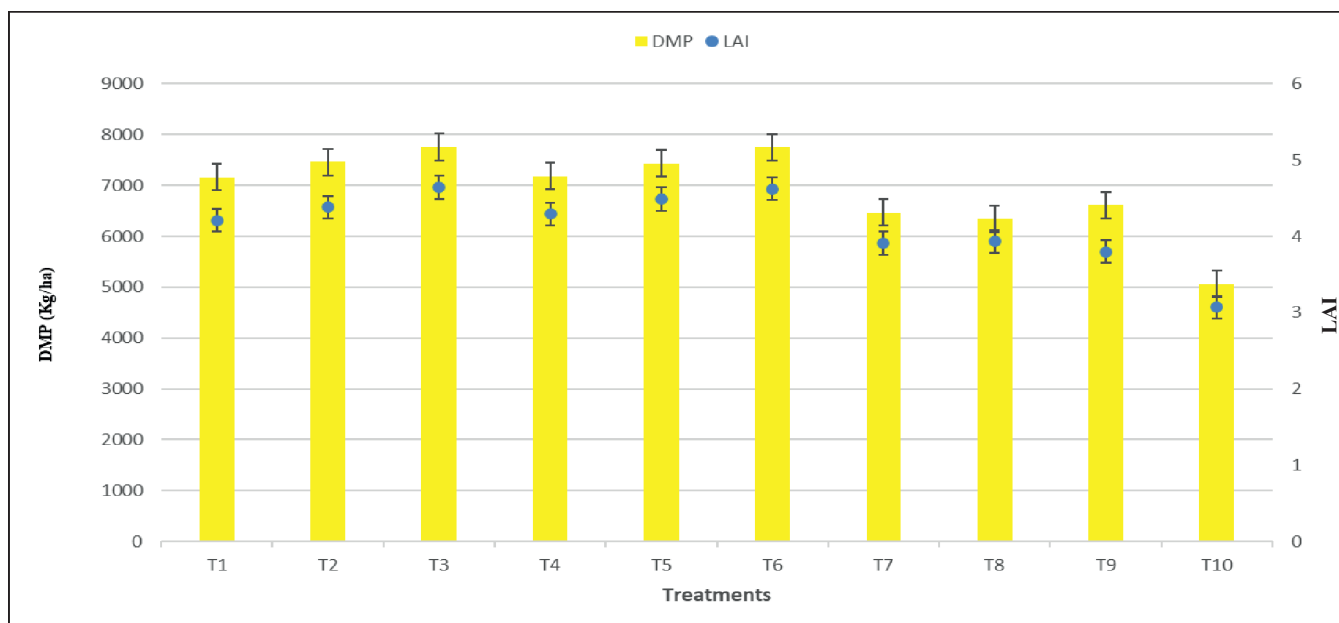
weight as the seeding rate of *Sesbania* increased (Table 1). *Sesbania* brown manuring at the seeding rate of 25 kg/ha + 2,4-D 0.5 kg/ha has significantly reduced the weed density (73.3 no./m²) and dry weight (37.0 g/m²) as compared to 15 and 20 kg/ha owing to better weed suppression offered by greater interference of *Sesbania* on weeds. Our results are in agreement with the findings of Behera *et al.*, (2018). Throughout the crop period, weed control efficiency (WCE) was higher (53.1 to 73%) with rice co-culture with *Sesbania* using 2,4-D and bispyribac sodium, and hand weeding twice (70.7%) owing to the fact that it registered lesser weed dry weight (Table 1). In terms of crop growth, brown manuring resulted in taller plants when compared to rice alone plots (Table 1). In particular, *Sesbania* seeding rate for BM @25 kg/ha + 2,4-D 0.5 kg/ha recorded the higher plant height (132.8 cm), leaf area index (LAI) (4.64) and dry matter production (7750 kg/ha) and was at par with *Sesbania* seeding rate for BM @25 kg/ha + bispyribac sodium 25 g/ha but superior to rice alone and unweeded control (Table 1 and Fig. 1). Improved crop growth under brown manuring treatments might be owing to reduced interference of weeds for growth resources, increased availability of nutrients from quick decomposition of *Sesbania* residue. Increase in plant height and LAI, improved the photosynthesis process of the crop, resulted in enhanced crop growth rate (CGR) (528.2 and 529.2 g/m²/day) and ultimately led to earlier flowering (81 to 82 days) under rice with brown manured treatments when compared to rice alone and unweeded control.

Yield potential of any crop is decided by the cumulative effect of its yield attributing characters into total biological yield. *Sesbania* seeding rate for BM @25 kg/ha + 2,4-D 0.5 kg/ha resulted in the maximum panicle weight (3.7 g) whereas it was lowest (2.2 g) in unweeded control plot. The higher grain yield (4823 kg/ha) was recorded with *Sesbania* seeding rate for BM @25 kg/ha + 2,4-D 0.5 kg/ha which was on par with *Sesbania* seeding rate for BM @25 kg/ha + bispyribac sodium 25 g/ha (Table 1). The lowest grain yield was recorded in unweeded control plot (1,904 kg/ha). Higher value of yield and yield attributes under *Sesbania* seeding rate for BM @25 kg/ha + 2,4-D 0.5 kg/ha might be owing to the minimum weed competition during critical growth period. Effective control of weeds in these treatments paved way for enhanced availability of nutrients, sun light and other resources for improving the yield and yield attributes of rice which ultimately enhanced the grain yields. The decomposed leaves of *Sesbania* acted as mulch and provided additional nutrients to the crop during grain filling period which accounted to 87.5% higher grain yield than unweeded control (Behera *et al.*, 2018; Chaudhary *et al.*, 2018). However, the lower panicle weight was recorded in unweeded control, which

Table 1. Effect of brown manuring practices on weed dynamics, crop growth and yield, and energetics in wet seeded rice

Treatment	Total weed density (no./m ²)	Total weed dry weight (g/m ²)	Weed control efficiency (%)	Plant height (cm)	Days to 50% flowering	Crop growth rate (g/m ² /day)	Panicle weight (g)	Grain yield (kg/ha)	Energy productivity (kg/MJ)	Energy profitability (kg/MJ)	Energy use efficiency
BM @15 kg/ha + 2,4 D @0.5 kg/ha	10.91 (118.7)	8.05 (64.5)	53.1	121.3	81	510.9	3.2	4,231	0.52	6.65	7.65
BM @20 kg/ha + 2,4 D @0.5 kg/ha	10.35 (106.7)	7.69 (58.7)	57.3	127.4	81	512.5	3.3	4,376	0.55	7.03	8.03
BM @25 kg/ha + 2,4 D @0.5 kg/ha	8.57 (73.3)	6.09 (37.0)	73.0	132.8	82	528.2	3.7	4,823	0.60	7.77	8.77
BM @15 kg/ha + bispyribac sodium @25 g/ha	10.94 (119.3)	8.15 (66.0)	52.0	121.7	81	511.7	3.2	4,248	0.54	6.90	7.90
BM @20 kg/ha + bispyribac sodium @25g/ha	10.28 (105.3)	7.58 (57.1)	58.5	127.8	81	516.8	3.3	4,433	0.56	7.17	8.17
BM @25 kg/ha + bispyribac sodium @25g/ha	9.21 (84.7)	6.42 (40.1)	70.4	132.5	81	529.2	3.6	4,789	0.59	7.74	8.74
2,4 D @0.5 kg/ha	11.88 (140.7)	8.78 (76.7)	44.2	119.2	82	512.3	3.1	3,739	0.48	6.12	7.12
Bispyribac sodium @25 g/ha	12.13 (146.7)	8.69 (75.0)	45.4	120.0	82	516.7	3.0	3,829	0.50	6.32	7.32
Hand weeding twice at 20 and 40 DAS	9.85 (96.7)	6.37 (40.2)	70.7	115.6	82	505.6	3.5	4,340	0.54	6.96	7.96
Unweeded control	16.53 (272.7)	11.74 (137.4)	-	106.4	84	262.2	2.2	1,904	0.25	2.67	3.67
SEm±	0.38	0.28	-	2.35	0.47	27.99	0.13	128.2	-	-	-
CD (P=0.05)	0.80	0.60	-	4.94	1.01	58.81	0.27	269.4	-	-	-

BM, Seeding rate of *Sesbania* for brown manuring in rice co-culture; DAS, Days after sowing. The data are square root transformed and figure in the parenthesis are original values.

**Fig. 1.** Effect of brown manuring practices on dry-matter production (DMP) and leaf area index (LAI) in wet seeded rice.

ultimately reduced the yield. Similarly, all brown manuring practices significantly enhanced the grain yield as compared to unweeded control.

Sesbania seeding rate for BM @ 25 kg/ha + 2,4-D 0.5 kg/ha and @ 25 kg/ha + bispyribac sodium 25 g/ha registered the highest energy productivity (0.60 and 0.59 kg/MJ), energy profitability (7.77 and 7.74 MJ/ha) and energy use efficiency (8.77 and 8.74), respectively. It is quite in-

teresting to note that better energy use efficiency observed under brown manuring treatment might be owing to higher grain yield, which would have offset the higher energy spent for herbicide application and increased seed rate (Table 1). Similar trend was observed in *Sesbania* seeding rate for BM @ 25 kg/ha + bispyribac sodium 25 g/ha treatment also. The lowest energy productivity (0.25), energy profitability (2.67) and energy use efficiency (3.67) were

recorded in unweeded control due to poor grain yield.

Based on the study, it can be concluded that *Sesbania* seeding rate @25 kg/ha coupled with application of either 2,4-D 0.5 kg/ha or bispyribac sodium 25 g/ha to knock down *Sesbania* for brown manuring would result in better crop growth, rice grain yield and energy use efficiency in wet seeded rice.

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