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RESEARCH ARTICLE

Effect of 2,4-D dose and formulation for brown manuring on weed dynamics, yield and economics in wet seeded rice

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ABSTRACT

Field experiments were conducted during 2021 and 2022 with twelve treatments on sandy clay loam soil in randomized block design (RBD), replicated thrice. The treatment consisted of rice co-culture with *Sesbania bispinosa* (*Sesbania*) and applied with different formulations of 2,4-D sodium salt, ethyl-ester and amine at varied levels (0.50, 0.75 and 1.0 kg/ha), hand weeding twice, weed free and unweeded control. Application of 2,4-D ethyl-ester 1.0 kg/ha proved effective in weed management by exhibiting significantly lower densities of grass (70.7/m^2), sedges (14.7/m^2), and broad-leaved weeds (0.0/m^2) with higher weed control efficiency of 74.3% at 60 DAS. Brown manuring through application of 2,4-D ethyl-ester 1.0 kg/ha led to higher grain yield (3.62 t/ha) and B:C ratio (2.03) and it was followed by 2,4-D sodium salt 1.0 kg/ha. Therefore, 2,4-D ethyl-ester 1.0 kg/ha can be recommended for effective brown manuring and eco-friendly weed management in rice, which would provide higher rice grain yield and B: C ratio. The next best treatment was rice co-culture with dhaincha and applied with 2,4-D sodium salt 1.0 kg/ha in wet seeded rice of deltaic coastal ecosystem.

Key words: Wet seeded rice, Brown manuring, *Sesbania*, 2,4-D formulations

INTRODUCTION

Rice (*Oryza sativa* L.) is the principal source of food for more than half of the world's population who depends for daily sustenance. India is the second largest producer and consumer of rice in the world, which occupies an area of 45.07 million hectares with the total production and productivity of 122.27 million tonnes and 2,713 kg/ha, respectively.

Rice is mostly grown as transplanted crop which demands high quantity of water along with various intercultural operations like land preparation, puddling, nursery raising, transplanting *etc*. and thus, increases cost of cultivation (Maity and Mukherjee 2009). Therefore, direct seeding of pre-germinated rice seeds can be a suitable alternative for transplanting and weeds control. Weed infestation in wet seeded rice can cause around 45-90% yield reduction (Saravanane and Chellamuthu 2016). Success of wet seeded rice depends on effective weed management strategy as well as better soil health. These twin objectives may be very well achieved through brown manuring. Rice and *Sesbania bispinosa* (*Sesbania*) also known as *Sesbania aculeata*, are co-cultured, and killed by spraying a selective post emergence (PoE) herbicide after 25-30 days of sowing (Tanwar *et al*. 2010). These *Sesbania* plants turn into brown colour due to knock down effect of the selective post-emergence herbicide and die, hence they are called brown manure plants. The dead plants are kept standing in the field without incorporating into the soil, allowing the residues of brown manure plants to fall and cover the soil surface as well as to decompose and add nutrients and organic carbon into the soil. This practice is mostly noticed in direct-seeded rice under the cases of both line sowing and broadcasting rather than in transplanted rice. Brown manuring is the zero tilled version of green manuring, one of the weed suppression and carbon farming approaches to manage weeds and sequester carbon. Brown manure can suppress or smother weeds by occupying land space and early accumulating dry matter or shading through greater canopy coverage. In general, herbicides hold the major role in the success of brown manuring and the use of post-emergence selective herbicides, *viz*. 2,4-D and bispyribac-sodium, in particular. Keerthi *et al*. (2022) revealed that knocking down of *Sesbania* using 2,4-D was found to be the best compared to use of bispyribac-sodium. However, very less research works has been carried out on the 2,4-D formulation and different doses used for brown manuring, Thus, keeping the above information, two season experiment were conducted to study the "Effect of 2,4-D dose and

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formulation for brown manuring on weed dynamics, yield and economics in wet seeded rice" at Karaikal, Puducherry, U.T.

MATERIALS AND METHODS

Field experiments were conducted under puddled condition at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal during June to October, 2021 and January to May, 2022. The experimental site was located at 10° 55′ North latitude and 79° 49′ East longitude and at an altitude of 4 m above the mean sea level. The soil has a sandy clay loam texture with a pH of 6.7 and EC 0.17 dS/m, respectively. The soil fertility status was low in available nitrogen (206.9 kg/ha), high in available phosphorus (29.7 kg/ha) and medium in available potassium (171.6 kg/ha), respectively. The experiment was carried out with twelve treatments, *viz.* 2,4-D sodium salt 0.50 kg/ha, 2,4-D sodium salt 0.75 kg/ha, 2,4-D sodium salt 1.0 kg/ha, 2,4-D ethyl-ester 0.50 kg/ha, 2,4-D ethyl-ester 0.75 kg/ha, 2,4-D ethyl-ester 1.0 kg/ha, 2,4-D amine 0.50 kg/ha, 2,4-D amine 0.75 kg/ha, 2,4-D amine 1.0 kg/ha, hand weeding twice at 15 and 30 DAS (farmer's practice), weed free and unweeded control in a randomized block design with three replications. Treatments from T_1 to T_9 were maintained uniformly with rice co-culture with *Sesbania* upto 28 DAS.

Pre-germinated rice seeds of *ASD 16* variety were sown in line by adopting a spacing of 15 x 10 cm. *Sesbania* seeds (25 kg/ha) were evenly broadcasted on the same day of rice sowing. 2,4-D formulations were sprayed on 28 days after sowing as per the treatment schedule. The field was irrigated one week after sowing and subsequent irrigations were given as and when needed depending on the soil moisture condition. A recommended dose of fertilizers (150:50:50 kg N:P:K/ha) was applied as urea, single superphosphate and muriate of potash, respectively. The entire quantity of phosphorus and half dose of K was applied as basal dose in all the plots. Nitrogen was applied in three splits (50%, 25% and 25%) at 15 DAS, maximum tillering stage and flowering stage, respectively. The remaining 50% of K was applied in two splits along with N at maximum tillering stage and flowering stage, respectively. Thrips were managed by spraying thiomethoxam 25% WG (0.4 g/L). Data on weed density were recorded at 60 DAS using quadrate of size 0.5 m x 0.5 m placed at two random places in each plot and the relative density (RD) was computed using standard formula. Weeds were cut at ground level during weed observation at 60 DAS, washed with running water, sun-dried, oven-dried at 70°C for 48 h, and then weighed to record weed biomass. Rice grain yield was measured from the net plot leaving the border rows and expressed in t/ha at 14% moisture content.The data on weed density and dry weight was transformed to square root transformation ($\sqrt{x+0.5}$) to normalize their distribution before analysis. Grain yield and weed biomass relationships at harvest were assessed using linear regression analysis. The experimental data were subjected to standard statistical analysis.

RESULTS AND DISCUSSION

Effect on weeds

The weed flora of the experimental field consisted of grasses (3 species), sedges (3 species) and broad-leaved weeds (6 species). Grasses made up the majority, representing 47.7% season and 44.2% during 2021 and 2022, respectively. Among grasses, *Leptochloa chinensis* (22.1%) was the most prevalent during and followed by *Echinochola crusgalli* (19.9%). *Cyperus difformis* (13.7 and 14.9%) and *Eclipta alba* (5.9 and 6.3%) were dominant among sedges and BLW's in both years, respectively (**Table 1**).

Formulations and doses of 2,4-D influenced the weed density (**Table 2**). 2,4-D ethyl-ester 1.0 kg/ha had the lowest grass weed density at 70.7/m^2 closely followed by 2,4-D sodium salt and 2,4-D amine, with grass weed densities of 85.3/m^2 and 86.7/m^2, respectively. The 2,4-D ethyl-ester treatment recorded lower densities of sedges (14.7/m^2) and broad-leaved weeds respectively. Effectiveness of 2,4-D ethyl-ester was attributed to the lipid-soluble nature of esters, facilitating quicker absorption through the plant's surface and inducing uncontrolled growth, leading to the demise of susceptible weed plants (Tanwar *et al.* 2010). Similar trend was observed with weed dry weight in both seasons. 2,4-D ethyl-ester 1.0 kg/ha significantly exhibited the lowest dry weight of grassy, sedges, broad-leaved and total weeds, respectively. This efficacy may be attributed to the suppression of *Sesbania* by ethyl-ester, which forms a residue mulch on the soil surface, hindering weed emergence by limiting sunlight and providing a physical barrier. Moreover, 2,4-D ester, being a selective herbicide, acidifies weed cell walls, inducing uncontrolled cell elongation, RNA, DNA, and protein synthesis, leading to excessive cell division and vascular tissue destruction, resulting in the death of susceptible broad-leaved weeds and sedges (Sraw *et al.* 2017) (**Table 2**). Among the brown manuring treatments, rice co-culture with *Sesbania* and applied with 2,4-D ethyl-ester 1.0 kg/ha recorded higher WCE of 74.3 per cent at different crop growth stages. Similar results of higher weed control efficiency were recorded by Datta *et al*. (2017). All the brown manuring practices lowered the total weed density at all the stages of crop growth which might be due to vigorously growing *Sesbania* that smothered and reduced the photosynthetic activity of weeds by intercepting light leading to greater reduction in weed interference (Anitha *et al*. 2012).

Effect on crop

Among the brown manuring treatments, 2,4-D ethyl-ester 1.0 kg/ha recorded better plant height (87.7 cm) and LAI (3.92) and rice yield (3.62 t/ha), and found to be on par with 2,4-D sodium salt 1.0 kg/ha, 2,4-D amine 1.0 kg/ha and 2,4-D ethyl-ester 0.75 kg/ha (**Table 3**). 2,4-D ethyl-ester 1.0 kg/ha gave 56% higher grain yield compared to unweeded control). This might be due to higher weed control efficiency, increased plant height, increased number of leaves/plant attributed to increase in the size of the photosynthetic area. Nawaz *et al*. (2017) reported that brown manuring supplied substantial amount of nitrogen which favoured in increasing leaf area and dry matter production. Maintaining weed free condition throughout crop growth recorded superior growth and higher rice yield (3.95 t/ha) whereas the unweeded control recorded a lower grain yield of 1.95 t/ha (**Table 3**). Effective controlling of weeds might have enhanced the availability of nutrients, soil moisture and other resources which in turn improving the growth and yield attributes of rice, which ultimately enhanced the grain and straw yield (Kumari and Kaur 2016). Significant negative correlation of weed dry weight was observed with grain yield (**Figure 1**). This might be due to decrease in the grain due to decrease control of weeds. Weed index (WI), is a measure of crop yield reduction due to weed competition in comparison to weed free. All the brown manuring treatments, substantially

Table 1. Weed floristic composition in the experimental field

Botanical name	Common name	Vernacular name	Family	Relative density (%) 2021	Relative density (%) 2022
Grasses					
Echinochloa colona Link.	Jungle grass	*Kudirai vali*	Poaceae	7.2	7.9
Echinochola crus-galli L.	Barnyard grass	*Koravampul*	Poaceae	18.4	19.9
Leptochloa chinensis (L.) Nees.	Chinese sprangletop	*Vakka pul*	Poaceae	22.1	16.4
Total grasses				47.7	44.2
Sedges					
Cyperus difformis L.	Variable flatsedge	*Vattakorai*	Cyperaceae	13.7	14.9
Cyperus iria L.	Ricefield flatsedge	*Pookorai*	Cyperaceae	5.8	6.2
Fimbristylis miliacea L.	Hoorah grass	-	Cyperaceae	10.4	10.6
Total sedges				29.9	31.7
Broad-leaved weeds					
Bergia capensis L.	Cape ash	*Nandukal keerai*	Elatinaceae	2.4	2.8
Eclipta alba (L.) Hassk	False daisy	*Karisilanganni*	Asteraceae	5.9	6.3
Hydrolea zeylanica (L.) Vahl	Ceylon hydrolea	*Vellel*	Hydrophyllaceae	4.6	5.3
Ludwigia perennis L.	Water primerose	*Neerkerambu*	Onagraceae	2.2	2.4
Marsilea quadrifolia L.	European waterclover	*Allakodi*	Marsileceae	2.8	3.6
Sphenoclea zeylanica Gaertn.	Goose weed	*Neer thipili*	Sphenocleaceae	4.5	3.7
Total broad-leaved weeds				22.4	24.1
Total no. of weeds				100%	100%

Table 2. Weed density and dry weight as influenced by brown manuring practices at 60 DAS in wet seeded rice (pooled data of 2 seasons)

Treatment	Grass weeds		Sedge weeds		Broad-leaved weeds		Total weeds	
	Density (no./m^2)	Dry weight (g/m^2)	Density (no./m^2)	Dry weight (g/m^2)	Density (no./m^2)	Dry weight (g/m^2)	Density (no./m^2)	Dry weight (g/m^2)
2,4-D sodium salt 0.50 kg/ha	10.67(113.2)	8.13(65.6)	8.00(64.0)	4.36(18.6)	4.10(16.3)	2.79(7.3)	13.9(193.5)	9.59(91.5)
2,4-D sodium salt 0.75 kg/ha	9.97(98.8)	7.82(60.6)	5.10(25.7)	2.72(6.9)	3.20(9.8)	2.34(5.0)	11.6(134.3)	8.54(72.6)
2,4-D sodium salt 1.0 kg/ha	9.23(85.3)	7.06(49.3)	3.97(15.3)	1.93(3.3)	0.70(0.0)	0.71(0.0)	10.1(100.7)	7.28(52.6)
2,4-D ethyl-ester 0.50 kg/ha	10.70(113.7)	7.55(56.7)	7.97(63.0)	4.34(18.4)	3.60(12.7)	2.58(6.2)	13.8(189.3)	9.04(81.3)
2,4-D ethyl-ester 0.75 kg/ha	9.83(96.0)	7.29(52.7)	4.60(20.8)	2.42(5.4)	2.47(5.8)	2.02(3.6)	11.1(122.7)	7.88(61.7)
2,4-D ethyl-ester 1.0 kg/ha	8.43(70.7)	6.14(37.3)	3.87(14.7)	2.01(3.6)	0.70(0.0)	0.71(0.0)	9.26(85.3)	6.43(40.9)
2,4-D amine 0.50 kg/ha	11.37(128.5)	8.13(65.6)	6.57(42.5)	3.59(12.4)	4.50(19.8)	2.97(8.3)	13.8(190.8)	9.32(86.3)
2,4-D amine 0.75 kg/ha	10.70(113.8)	7.79(60.2)	4.10(16.3)	2.10(4.0)	3.50(12.0)	2.51(5.8)	11.9(142.2)	8.39(70.0)
2,4-D amine 1.0 kg/ha	9.33(86.7)	7.31(53.0)	4.00(15.5)	1.94(3.3)	0.70(0.0)	0.71(0.0)	10.1(102.2)	7.53(56.3)
Hand weeding twice	6.77(45.2)	6.90(47.1)	9.67(92.8)	5.25(27.1)	7.23(51.8)	4.38(18.7)	13.8(189.8)	9.67(93.0)
Weed free	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)
Unweeded control	13.83(192.2)	9.51(90.0)	11.33(128.0)	6.17(37.6)	9.83(96.3)	5.66(31.6)	20.4(416.2)	12.63(159.2)
LSD(p=0.05)	0.47	0.38	0.46	0.25	0.41	0.20	0.55	0.36

Figures in parentheses are original values, Data were subjected to square root transformation ($\sqrt{x+0.5}$)

Table 3. Growth, yield and B:C ratio influenced by brown manuring practices in wet seeded rice

Treatment	Plant height (cm)	LAI	Grain yield (t/ha)			Weed index	Net returns (`/ha)	B:C ratio
			2021	2022	Pooled			
2,4-D sodium salt 0.50 kg/ha	81.8	2.54	2.73	3.40	3.07	22.6	25507	1.78
2,4-D sodium salt 0.75 kg/ha	83.7	2.73	2.80	3.37	3.08	22.1	25634	1.78
2,4-D sodium salt 1.0 kg/ha	85.0	3.43	3.10	3.63	3.37	14.9	30992	1.94
2,4-D ethyl-ester 0.50 kg/ha	80.2	2.33	2.50	2.77	2.63	33.4	16978	1.51
2,4-D ethyl-ester 0.75 kg/ha	84.1	3.33	2.60	2.90	2.75	30.5	19041	1.57
2,4-D ethyl-ester 1.0 kg/ha	87.7	3.92	3.50	3.73	3.62	8.5	34759	2.03
2,4-D amine 0.50 kg/ha	77.5	2.45	2.30	2.97	2.63	33.6	17228	1.52
2,4-D amine 0.75 kg/ha	81.3	3.15	2.50	3.20	2.85	28.1	21100	1.64
2,4-D amine 1.0 kg/ha	84.7	3.43	3.03	3.47	3.25	17.8	28558	1.86
Hand weeding twice	84.4	3.02	2.97	3.43	3.20	19.1	21192	1.53
Weed free	89.4	4.18	3.80	4.10	3.95	0.0	11050	1.18
Unweeded control	75.9	1.92	1.80	2.10	1.95	50.7	6625	1.22
LSD (p=0.05)	4.28	0.64	0.42	0.81	0.44	-	-	-

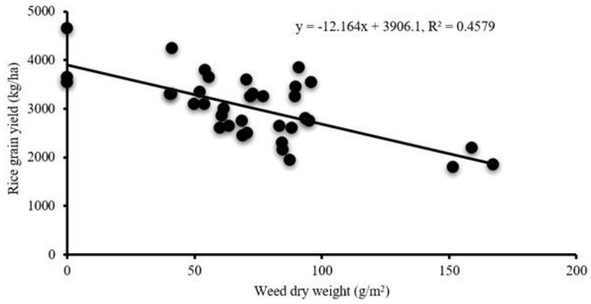

Figure 1. Relationship between grain yield and weed dry weight in wet seeded rice (pooled mean)

reduced the competition by weeds and thus registered lower weed index. Among the brown manuring treatments, 2,4-D ethyl-ester 1.0 kg/ha recorded lower weed index (8.5) followed by 2,4-D sodium salt 1.0 kg/ha, 2,4-D amine 1.0 kg/ha. However, higher weed index was recorded under unweeded control (50.7%).

Economics

Managing the weeds enhanced the net return and B:C ratio as compared to unweeded control. Among the brown manuring treatments, the maximum net return (₹ 34759/ha) and the B:C ratio (2.03) were obtained in 2,4-D ethyl-ester 1.0 kg/ha followed by 2,4-D Na salt 1.0 kg/ha (₹ 30992/ha) and B:C ratio (1.94). This may be due to higher grain yield obtained due to effective suppression of weed growth and less cost of cultivation. These findings are in line with Tanwar *et al*. (2010). Significantly lower net return was obtained under unweeded control ₹ 6625/ ha). Lower B:C ratio (1.18) was recorded weed free condition due to utilization of more labours for weeding, which lead to higher cost of cultivation (Anitha *et al.* 2012).

Conclusion

Thus, it was concluded that rice co-culture with *Sesbania* and applied with 2,4-D ethyl-ester 1.0 kg/ha was effective in minimizing weed population, weed dry weight, crop weed competition and enhancing crop growth, grain yield and economics. In case of non-availability of 2,4-D ethyl-ester, other promising formulation of 2,4-D sodium salt 1.0 kg/ha can be used in wet seeded rice.

REFERENCES

Anitha S, Mathew J and Abraham CT. 2012. Concurrent growing of green manure with wet-seeded rice for cost-effective weed management. *Indian Journal of Weed Science* **44**(1): 34–37.

Datta MK, Kundu CK, Singharoy S and Sarkar SK. 2017. Effectiveness of 2,4-D ethyl-ester 80% EC to control of weeds in *kharif* rice. *Journal of Crop and Weed* **13**(1): 196–199.

Keerthi DE, Saravanane P, Poonguzhalan R, Nadaradrajan S, Muthukumarasamy S and Vijayakumar S. 2022. Effect of brown manuring on weed dynamics, crop productivity, economics and energetics in wet seeded rice in coastal deltaic ecosystem. *Oryza* **59**(4): 519–524.

Kumari S and Kaur T. 2016. Effect of brown manuring and herbicides on growth, nitrogen uptake and weed dynamics in direct-seeded rice (*Oryza sativa L.). International Journal of Bioresource and stress Management* **7**(6): 1249–1254.

Maity SK and Mukherjee PK. 2009. Effect of brown manuring on grain yield and partial factor productivity of nutrients in dry direct-seeded summer rice (*Oryza sativa* L.) under Terai-agro-ecological region of West Bengal. *Journal of Crop and Weed* **5**(2): 31–35.

Nawaz A, Farooq M, Lal R, Rehman A, Hussain, T and Nadeem A. 2017. Influence of *Sesbania* brown manuring and rice residue mulch on soil health, weeds and system productivity of conservation rice-wheat systems. *Land Degradation and Development* **28**: 1078–1090.

Saravanane P and Chellamuthu V. 2016. Seeding method and weed competition effect on growth and yield of direct-seeded rice under puddled condition. *Indian Journal of Weed Science* **48**(3): 323–324.

Sraw PK, Kaur A and Singh K. 2017. To assess the scope of brown manuring in aerobic rice in central Punjab. *Journal of Crop and Weed* **13(**1): 17–22.

Tanwar TS, Singh T and Lal B. 2010. Weed management in paddy. *Popular Kheti* **1**(2): 130–135.