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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

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ABSTRACT

A field experiment was conducted during summer season of 2007 and 2008 for generating information on weed flora and to workout integrated weed management practices with its economics in dry direct seeded summer rice. Among the weed flora grasses like, Cynodon dactylon, Echinochloa crus-galli, Digitaria sanguinalis, Brachiaria ramosa, sedges like Cyperus pilosus, Cyperus iria and broad leaved weeds like Amaranthus viridis, Solanum nigrum, Euphorbia hirta, Commelia diffusa, Phyllanthus niruri, Chinopodium album, Alternanthera sp., Physalis minima, Polygonum pensylvanicum, Polygonum orientale and Polygonum persicarea were recorded during experimentation. Among the integrated weed management practices, butachlor 1.25 kg ha^{-1} as pre-plant surface application + brown manuring + 2,4-D 0.50 kg ha^{-1} at 40 days after sowing recorded highest grain yield (4.36 and 4.18 t ha^{-1}) and it was statistically at par with the grain yield (4.44 and 4.22 t ha^{-1}) obtained from long weed free situation. Highest net return (Rs 21954 and 20494 ha^{-1}) and benefit cost ratio (1.30 and 1.22) were also recorded in this treatment during both the years. Therefore, this integrated weed management practice became effective in dry direct seeded summer rice under Terai agro-ecological region of West Bengal. There has been considerable improvement in partial factor productivity of the nutrients due to adoption of weed control practices coupled with nitrogen management and among the integrated weed management practices, partial factor productivity of N (43.60 and 41.80 kg grain yield/kg nutrient applied), P (250 and 239.68 kg grain yield/kg nutrient applied) and K (87.55 and 83.94 kg grain yield/kg nutrient applied) were highest with butachlor 1.25 kg ha^{-1} + brown manuring + 2,4-D 0.5 kg ha^{-1} in both the years.

Key words: Brown manuring, direct seeded, integrated weed management, partial factor productivity and weed flora,

Rice is cultivated as irrigated crop under transplanted ecosystem during *summer* season in *Terai* agro-ecological region of West Bengal. Intermittent rain occurring during winter season led to create an opportunity to grow *summer* rice in low land situation. High cost involved in irrigation water and engagement of manual labourers for seed bed preparation, puddling and transplanting operation reduce profit margin of summer rice cultivation. Moreover most of the farmers in these areas are marginal in nature and unable to bear the cost in carrying out these operations. Direct seeding with pre-germinated rice seed in unpuddled condition could be an effective option to curtail several operations of transplanted rice cultivation, reduce engagement of manual labourers and irrigation water. Weeds in dry direct seeded rice are considered as a major constraint in direct seeded rice cultivation. Weeds decreased grain yields by 12.6 to 15.6% in no-till direct seeded winter rice (Itoh and Takahashi, 1997). Fractional application of nitrogen in right amount and proportion coupled with weed control practices facilitates higher absorption of applied nitrogen and thus increasing efficiency of fertilizer nitrogen (Amarjit *et al.,* 2006). In this context the present investigation was carried out to find out economically viable integrated weed management strategy in dry direct seeded *summer* rice.

MATERIALS AND METHODS

Field experiment was conducted at the instructional research farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar ($25^0 57'$ N-27^0 N latitude and $88^0 25'$ E-$89^0 54'$ E longitude), West Bengal during *summer* season of 2007 and 2008. The climate in this region is humid and characterized with high rainfall (300 cm year^{-1}). The soil is sandy to sandy loam with a pH of 5.05 and 0.72% organic C. Soil low in available N (127.92 kg ha^{-1}), medium in available P (21.59 kg ha^{-1}) and low in available K (122.46 kg ha^{-1}). There were 12 treatment combinations, viz. butachlor 1.25 kg ha^{-1} used as pre-plant surface application + hoeing at 30 days after sowing (DAS) + 2,4-D 0.5 kg ha^{-1} used as post-emergence at 40 DAS; pretilachlor 0.6 kg ha^{-1} as pre-plant surface application + hoeing at 30 DAS + 2,4-D 0.5 kg ha^{-1} as post-emergence at 40 DAS; pendimethalin 0.6 kg ha^{-1} as pre-plant surface application + hoeing at 30 DAS + 2,4-D 0.5 kg ha^{-1} as post-emergence at 40 DAS; benthiocarb 1.5 kg ha^{-1} as pre-plant surface application + hoeing at 30 DAS + 2,4-D 0.5 kg ha^{-1} as post-emergence at 40 DAS; butachlor 1.25 kg ha^{-1} as pre-plant surface application + brown manuring + 2,4-D 0.5 kg ha^{-1} as post-emergence at 40 DAS; pretilachlor 0.6 kg ha^{-1} as pre-plant surface application + brown manuring + 2,4-D 0.5 kg ha^{-1} as post-emergence at 40 DAS; pendimethalin 0.6 kg ha^{-1} as pre-plant surface application + brown manuring + 2,4-D 0.5 kg ha^{-1} as post-emergence at 40 DAS; benthiocarb 1.5 kg ha^{-1} as pre-plant surface application + brown manuring + 2,4-D 0.5 kg ha^{-1} as post-emergence at 40 DAS; PIIH-2023 (bispyribac sodium) 25 g ha^{-1} as post-emergence at 20 DAS + hoeing at 30 DAS + 2,4-D

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0.5 kg ha^{-1} as post-emergence at 40 DAS; season long weedy; season long weed free and, farmers' practice comprising three hand weeding at 15, 30 and 50 DAS. In moisture stress sandy to sandy loam soil of this region pre-plant surface application of herbicides increases selectivity than that of pre-emergence application.

The experiment was laid out in randomized block design with three replications. *Sesbania rostrata* (50 kg ha^{-1}) was grown for brown manuring in inter row spaces of 30 cm between paired row rice having the spacing of 15 cm. *Sesbania rostrata* was then killed by the application of 2,4-D @ 0.5 kg/ha at 25 DAS followed by its mulching with the help of paddy weeder. Pre-germinated seed (40 kg/ha) of rice 'GS-2'(Gotra Selection-2) was sown in rows 15 cm apart on 15 March 2007 and 29 March 2008 with the plot size of 8 m x 4.5 m. The fertilizer dose was 100 kg N, 40 kg P_2O_5 and 60 kg K_2O ha^{-1}. Nitrogenous fertilizer was applied in four splits i.e. ¼ at basal, ¼ at 25 DAS, ¼ at 45 DAS and ¼ at 60 DAS in all the treatments except under farmer's practice where application was made in three splits i.e. 1/3 at 15 DAS, 1/3 at 30 DAS and 1/3 at 60 DAS after hand weeding. Potassic fertilizer was applied in two splits i.e. ½ as basal and ½ at 70 DAS in all the treatments. The crop was irrigated twice during active tillering and grain filling stage. Weed dry weight was recorded using 50 cm x 50 cm quadrate from all the plots at 45 DAS. Data on weed dry weight (g/m^2) were subjected to square-root ($\sqrt{X + 0.5}$) transformation before statistical analysis. The weed control efficiency (WCE), weed index (WI) and partial factor productivity of nutrients (PFP) were calculated by using following formulae

$$\text{WCE (\%)} = \frac{\text{(Dry weight of weed in control plot – dry weight of weed in treated plot)}}{\text{Dry weight of weed in control plot}} \times 100$$

$$\text{WI (\%)} = \frac{\text{(Grain yield in complete weed free plot – grain yield in treated plot)}}{\text{Grain yield in complete weed free plot}} \times 100$$

$$\text{PFP} = \frac{\text{Grain yield (kg)}}{\text{Amount of nutrient applied (kg)}}$$

Economic analysis was done on the basis of prevailing market price of inputs used and the output obtained from each treatment (sale price of out put: rice grain Rs 7500/tonne; rice straw Rs 1000/tonne; input price: rice seed Rs 10 kg^{-1}; seed of *Sesbania rostrata* Rs 10 kg^{-1}; Urea, Rs 4.78 kg^{-1}; SSP, Rs 3.22 kg^{-1}; MOP, Rs 4.45 kg^{-1}; herbicides: butachlor (machete), Rs 180 litre^{-1}; pretilachlor (sofit), Rs 1550 litre^{-1}; pendimethalin (stomp), Rs 444 litre^{-1}; benthiocarb (saturn), Rs 384 litre^{-1}; PIIH-2023 (bispyribac sodium), Rs 4500 litre^{-1}; 2,4-D sodium salt, Rs 220 kg^{-1} ; labour wage, Rs 75.10 man day^{-1}).

RESULTS AND DISCUSSION

Effect on weed

The common weeds infesting the experimental field included grasses like *Cynodon dactylon, Echinochloa crus-galli, Digitaria sanguinalis, Brachiaria ramosa,* sedges like *Cyperus pilosus, Cyperus iria* and broadleaved weeds like *Amaranthus viridis, Solanum nigram, Euphorbia hirta, Commelia diffusa, Phylanthus niruri, Chinopodium album, Alternanthera sp., Physalis minima, Polygonum pensylvanicum, Polygonum orientale and Polygonum persicarea*. Grasses and sedges especially *Cyperus iria* appeared during initial growth stages whereas broadleaved weeds and other sedges especially *Cyperus pilosus* emerged after initial growth stage. Emergence of these weeds was observed during 20 to 30 DAS and there after it continuously emerged throughout the crop growth stages.

Results obtained from the experiment revealed that among the herbicide + cultural method of weed control, combination of butachlor 1.25 kg ha^{-1} + brown manuring + 2,4-D 0.5 kg ha^{-1} application at 40 DAS recorded lowest weed dry weight at 45 DAS leading to highest value of weed control efficiency of 85.38 % in 2007 and 83.46 % in 2008 at 45 DAS (Table 1). It was closely followed by pretilachlor 0.6 kg ha^{-1} + brown manuring + 2,4-D 0.5 kg ha^{-1} at 40 DAS (84.14 and 82.13 % in 2007 and 2008, respectively) and PIIH 2023 25 g ha^{-1} at 20 DAS + hoeing at 30 DAS + 2,4-D 0.5 kg ha^{-1} at 40 DAS (84.34 and 79.03 % in 2007 and 2008, respectively). Among the integrated weed management practices, butachlor + brown manuring + 2,4-D recorded lowest weed index of 3.75 % and 3.02 % in 2007 and 2008, respectively (Table 1). Highest value of weed control efficiency and lowest value of weed index of butachlor + brown manuring + 2,4-D reflected its selectivity and higher efficacy in controlling weeds. Butachlor + brown manuring + 2,4-D was able to reduce weed pressure as brown manuring acted as a cover crop in suppressing weed growth effectively at the initial growth stage. Ravisankar *et al.* (2008), Joseph *et al.* (2008), Sharma and Ghosh (2000) and, Angadi *et al*. (1993) also reported similar result.

Effect on crop yield

The highest grain (4.36 and 4.18 t ha^{-1}) and straw (6.11 and 6.00 t ha^{-1}) yield were recorded with butachlor 1.25 kg ha^{-1} + brown manuring + 2,4-D 0.5

kg ha^{-1} which was statistically at par with the grain (4.53 and 4.31 t ha^{-1}) and straw (6.37 and 6.17 t ha^{-1}) yield obtained from complete weed free condition during both the years. This was due to high weed control efficiency of the treatment (butachlor 1.25 kg ha^{-1} + brown manuring + 2,4-D 0.5 kg ha^{-1}) throughout the crop season without causing any crop phytotoxicity. Among the integrated weed management practices comprising herbicides + mechanical methods of weed control, PIIH 2023 25 g ha^{-1} at 20 DAS + hoeing at 30 DAS + 2,4-D 0.5 kg ha^{-1} at 40 DAS recorded highest grain (4.20 and 4.06 t ha^{-1}) and straw yield (5.99 and 5.86 t ha^{-1}) than butachlor 1.25 kg ha^{-1} + hoeing at 30 DAS + 2,4-D 0.5 kg ha^{-1}, pretilachlor 0.6 kg ha^{-1} + hoeing at 30 DAS + 2,4-D 0.5 kg ha^{-1}, pendimethalin 0.6 kg ha^{-1} + hoeing at 30 DAS + 2,4-D 0.5 kg ha^{-1} and benthiocarb 1.5 kg ha^{-1} + hoeing at 30 DAS + 2,4-D 0.5 kg ha^{-1} during both the years (Table 2). The grain yield during first year was higher than second year because of early sowing (15 March 2007) in the first year.

Effect on partial factor productivity of nutrients

Partial factor productivity of nutrients was positively influenced by weed management practices coupled with nitrogen management. Among the integrated weed management practices partial factor productivity of N (43.60 and 41.80 kg grain yield/kg nutrient applied), P (250 and 239.68 kg grain yield/kg nutrient applied) and K (87.55 and 83.94 kg grain yield/kg nutrient applied) were highest with butachlor 1.25 kg ha^{-1} + brown manuring + 2,4-D 0.5 kg ha^{-1} treated plots during both the years of experimentation in which nitrogen was applied in four splits. Skipping of basal dose of nitrogen in farmers' practice has considerable effect on partial factor productivity of the nutrients. Therefore, adoption of integrated weed management practice coupled with nitrogen management has considerably improved partial factor productivity over weedy condition, which in turn, reflected higher response of fertilizer nutrients on crop performance.

Economics

Among the integrated weed management practices butachlor 1.25 kg ha^{-1} + brown manuring + 2, 4-D 0.5 kg ha^{-1} registered highest net return (Rs 21954 and 20494 ha^{-1}) as well as benefit: cost ratio (1.30 and 1.22), during both the years. This might be owing to high weed control efficiency with least man days engagement and higher grain yield. The lower net return (Rs15993 and 14153 ha^{-1}) and benefit : cost ratio (0.68 and 0.6) in farmers' practice might be due to more man days engaged at 15, 30 and 50 DAS and that in turn considerably increased cost of cultivation (Table 2).

Thus integrated weed management practices comprising butachlor 1.25 kg ha^{-1} as pre-plant surface application + brown manuring + 2,4-D 0.5 kg ha^{-1} at 40 DAS could become effective in controlling weeds as well as getting higher yield during *summer* season in dry direct seeded rice ecosystem under *terai* agro-ecological region of West Bengal. There has been considerable improvement in partial factor productivity of the nutrients due to adoption of weed control practices coupled with nitrogen management.

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Table 1: Effect of treatments on dry weight of grass, sedge, broadleaf weed, weed control efficiency and weed index in dry direct seeded summer rice at 45 DAS

Treatment	Dry weight (g m^{-2})						Weed control efficiency at 45 DAS (%)		Weed index (%)	
	Grass		Sedge		Broadleaf weed					
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
Butachlor + BM + 2,4-D	1.55 (1.91)	1.83 (2.90)	1.42 (1.54)	1.39 (1.44)	1.70 (2.41)	2.01 (3.56)	85.38	83.46	3.75	3.02
Pretilachlor + BM + 2,4-D	1.64 (2.21)	1.93 (3.26)	1.44 (1.59)	1.42 (1.57)	1.73 (2.56)	2.04 (3.69)	84.14	82.13	5.52	4.18
Pendimethalin + BM + 2,4-D	1.79 (2.70)	2.10 (3.94)	1.60 (2.05)	1.87 (3.01)	1.86 (2.98)	2.32 (4.93)	80.72	75.09	9.05	6.96
Benthiocarb + BM + 2,4-D	1.85 (2.94)	2.13 (4.19)	1.64 (2.20)	1.91 (3.14)	1.97 (3.44)	2.42 (5.39)	78.57	73.33	10.38	8.12
Butachlor + hoeing + 2,4-D	1.69 (2.39)	2.04 (3.69)	1.57 (1.95)	1.73 (2.54)	1.76 (2.63)	2.17 (4.30)	82.61	77.92	13.02	12.06
Pretilachlor + hoeing + 2,4-D	1.76 (2.63)	2.10 (3.94)	1.65 (2.25)	1.82 (2.84)	1.99 (3.50)	2.30 (4.86)	79.10	75.59	15.67	13.22
Pendimethalin + hoeing + 2,4-D	1.84 (2.92)	2.17 (4.23)	1.73 (2.54)	1.99 (3.51)	2.02 (3.62)	2.51 (5.81)	77.40	71.59	18.54	16.94
Benthiocarb + hoeing + 2,4-D	1.95 (3.38)	2.26 (4.64)	1.83 (2.92)	2.08 (3.86)	2.29 (4.75)	2.68 (6.71)	72.46	68.11	19.65	18.33
PIIH-2023 + hoeing + 2,4-D	1.37 (1.39)	1.72 (2.47)	1.35 (1.35)	1.55 (1.97)	2.01 (3.54)	2.46 (5.56)	84.34	79.03	7.28	5.80
Season long weedy	3.77 (13.72)	4.07 (16.35)	2.62 (6.36)	2.58 (6.23)	4.52 (20.00)	5.04 (25.12)	0.00	0.00	76.16	80.51
Season long weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	100	100	0.00	0.00
Farmer's Practice	1.73 (2.52)	1.96 (3.35)	1.34 (1.30)	1.50 (1.83)	1.72 (2.47)	2.21 (4.45)	84.29	79.81	1.99	2.09
S.Em (±)	**0.13**	**0.24**	**0.12**	**0.16**	**0.16**	**0.23**	-	-	-	-
LSD (0.05)	**0.28**	**0.51**	**0.25**	**0.34**	**0.32**	**0.48**	-	-	-	-

Figures in the parentheses are original values, DAS-Days after sowing

Table 2: Effect of treatments on grain yield, straw yield, factor productivity of nutrients, net return and benefit: cost ratio of dry direct seeded summer rice

Treatment	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})		Partial factor productivity of nutrients (kg grain yield/kg nutrient applied)						Net return (Rs ha^{-1})		Benefit: cost ratio	
					N		P		K					
	2007	**2008**	**2007**	**2008**	**2007**	**2008**	**2007**	**2008**	**2007**	**2008**	**2007**	**2008**	**2007**	**2008**
Butachlor + BM + 2,4-D	4.36	4.18	6.11	6.00	43.60	41.80	250.00	239.68	87.55	83.94	21954	20494	1.30	1.22
Pretilachlor + BM + 2,4-D	4.28	4.13	6.06	5.96	42.80	41.30	245.41	236.81	85.94	82.93	18654	17429	0.96	0.89
Pendimethalin + BM + 2,4-D	4.12	4.01	5.87	5.84	41.20	40.10	236.24	229.93	82.73	80.52	19476	18621	1.13	1.08
Benthiocarb + BM + 2,4-D	4.06	3.96	5.80	5.79	40.60	39.60	232.80	227.06	81.53	79.52	18692	17932	1.06	1.02
Butachlor + hoeing + 2,4-D	3.94	3.79	5.57	5.54	39.40	37.90	225.92	217.32	79.12	76.10	19272	18117	1.22	1.14
Pretilachlor hoeing + 2,4-D	3.82	3.74	5.44	5.51	38.20	37.40	219.04	214.45	76.71	75.10	15592	15062	0.84	0.81
Pendimethalin + hoeing + 2,4-D	3.69	3.58	5.25	5.33	36.90	35.80	211.58	205.28	74.10	71.89	16639	15894	1.02	0.98
Benthiocarb + hoeing + 2,4-D	3.64	3.52	5.21	5.30	36.40	35.20	208.72	201.83	73.09	70.68	15960	15150	0.96	0.92
PIIH-2023 + hoeing + 2,4-D	4.20	4.06	5.99	5.86	42.00	40.60	240.83	232.80	84.34	81.53	20967	19787	1.27	1.20
Season long weedy	1.08	0.84	2.14	1.33	10.80	8.40	61.93	48.17	21.69	16.87	-3149	-5759	-0.24	-0.43
Season long weed free	4.53	4.31	6.37	6.17	45.30	43.10	259.75	247.13	90.96	86.55	13438	11588	0.50	0.43
Farmer's Practice	4.44	4.22	6.22	6.03	44.40	42.20	254.59	241.97	89.16	84.74	15993	14153	0.68	0.60
S.Em (±)	**0.39**	**0.30**	**0.44**	**0.57**	-	-	-	-	-	-	-	-	-	-
LSD (0.05)	**0.81**	**0.61**	**0.91**	**1.18**	-	-	-	-	-	-	-	-	-	-