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Influence of Integrated Weed Management Practices on Dynamics and Weed Control Efficiency in Dry Direct Seeded Rice

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Abstract

Field experiment under dry direct seeded rice(O*ryza sativa* L.) was conducted during rainy season of 2010 and 2011 at Regional Agriculture Research Station (RARS), Parwanipur, Bara to develop appropriate weed management practices for dry direct- seeded rice. The trial was laid-out in randomized complete block design (RCBD) and replicated thrice. Observations were taken on weed, plant growth and yield attributing, yield, and socio-economic parameters. The weed density, dry weed weight and weed control efficiency resulted significantly different as influenced by integrated weed management practices. Low weed population density, low weed index and highest weed control efficiency resulted by pendimethalin followed by 2, 4- D followed by one hand weeding were at par with weed free check. Highest yield resulted from weed free plot followed by pendimethalin followed by two hand weeding and pendimethalin followed by 2, 4- D followed by one hand weeding. However, the net return per unit investment resulted highest in pendimethalin followed by 2, 4- D followed by one hand weeding. This proved that amid increasing wage rate and labour scarcity integrated weed management through pendimethalin 30 EC (Stomp) @1 kg a. i. /ha as pre- emergence herbicide application followed by 2, 4- D sodium salt 80 WP @ 0.5 kg a. i. /ha followed by one hand weeding or stale seed bed followed by pendimethalin 30 EC (Stomp) @1 kg a. i. /ha followed by bispyribac (Nominee gold) @25 g a. i. /ha 10% @200 ml/ha at 20 days of seeding resulted best alternative for manual hand weeding practices giving higher net return per unit investment.

Key words: dry direct seeded rice, herbicide, 2,4-D, pendimethalin, and weed index

Introduction

Rice (*Oryza sativa* L.) is the main staple food of Nepalese people which has occupied the first position in terms of area coverage (1,531,493 ha) and production (5072248 mt) whereas average productivity is 3.31 t/ha, which is slightly in increasing trends (MoAD 2011/12) but the cost of cultivation is becoming high during these days due to increment in labor wages beside unavailability of labor in peak period of operation. Puddled transplanting is the dominant method of rice establishment in Asia including Nepal which provides multiple benefits to rice including reduction in weed population and percolation losses and increases availability of nutrients (Sanches 1973). However, it deteriorates soil physical properties ultimate adversely affects the growth and productivity of succeeding wheat crop. All these factors have increased the interest of farmers to shift from the conventional practice of puddled transplanting (CT- TPR) to direct seeded rice (DSR), especially dry DSR.

Direct seeded rice (DSR) is a cost effective rice establishment method where dry seed is drilled into the non-puddled soil. This provides opportunities of saving irrigation water by 12-35%, labour up to 60%

and provides higher net returns (US$30-50 ha^{-1}) with similar or slightly lower yield of rice (Kumar and Ladha 2011). Despite multiple benefits of dry- DSR, weed control remains one of the major challenges for its success in South Asia (Kumar and Ladha, 2011: Rao *et al*. 2007, Singh *et al.*, 2008). Weed control is more difficult in dry- DSR than CT- TPR because of simultaneously emerging rice seedlings with weeds in dry – DSR which are less competitive than 30-35 days old rice seedlings use in CT- TPR and initial flooding used in CT- TPR is effective for weed control but it is lacking in dry- DSR (Kumar and Ladha 2011, Rao *et al.* 2007).

Thus, weeds are the most severe constraint to aerobic rice production and timely weed management is crucial for increasing the productivity of aerobic rice. In Nepal, Ranjit (2007) observed that weeds caused yield loss in direct seeded rice ranging from 14-93 % where as in transplanted rice it was 17- 47 %. Most upland and aerobic rice growers in Asia mechanically weed their crops two or three times per season, investing up to 190 person days ha^{-1} in hand weeding (Roder 2001). Herbicides are considered to be an alternative/ supplement to hand weeding. Both Pre and Post-emergence herbicides can be used in aerobic rice fields, which are effective, if properly used (De Datta & Baltzar 1996, Singh *et al.* 2006).

For achieving effective weed control in dry- DSR, it is important to develop integrated weed management (IWM) program comprising of chemical, physical, cultural and biological methods built on a foundation of good knowledge of weed biology and ecology. The effective weed management practices include stale bed technique, crop rotation, zero tillage ZT, use of competitive varieties, water management, mulching, intercropping or cover crops and use of suitable chemicals at the right time.

The impact of the spread of direct seeding has been positive over all. DSR reduces the climatic risk caused by unpredictable monsoon rains, reducing dependence on pump sets and tractors for timely crop establishment which will benefit poor farmers. The use of direct seeding increases the opportunity for farmers to plant a winter crop on residual moisture. It also advances harvest by 18 days. Harvesting earlier reduces the risk of terminal drought at heading to maturity stage in rice at time of monsoon end which also abruptly increases opportunity for establishing post -rice winter crop. However, this type of research is less carried in our context. Therefore, the present experiment was conducted to develop effective and economical integrated weed management practices for dry direct-seeded rice.

Methodology

The experiment was conducted at the Regional Agricultural Research Station (RARS), Parwanipur, Bara during the rainy season of 2010 and 2011 in randomized block design replicated thrice. The site is located in the central piedmont of Nepal at 115 masl. at 27° 21'N and 84°53'E. The soil is an inceptisol formed on Himalayan residuum with the following characteristics in the top 15-cm profile: clay 8.0%, slit 17.0%, sand 75.0% (loamy sand), pH (1:2 soil:water) 7.0, total N 0.86 g kg^{-1}, total C 6.5 g kg^{-1}, NH_4OAc-extractable K 0.054 g kg^{-1}, Olsen p 0.015 g kg^{-1}, saturation extract exchangeable cations 1.4 dS m^{-1}, and bulk density 1.6 Mg m^{-3}.

Ten different weed management practices were tested against weedy and weed free check. For stale seed bed glyphosate 41% @1kg a.i/ha and paraquat @ 0.5 kg a.i/ha were applied before one week of seeding. Pendimethalin 30 EC (Stomp) @ 1 kg a.i/ha were as a pre-emergence herbicide in moist condition at evening hours in five treatments. Mulching (wheat straw) @ 4.0 t/ha was done on the next day. Bispyribac sodium (Nominee gold) 10% @ 25 g a.i/ha @ 200ml/ha was applied at 20 days of seeding as post-emergence. 2, 4-D sodium salt (80 WP) was applied @ 0.5 kg a.i/ha at 30 days after seeding to kill *Sesbania*. Continuous weeding was done to weed free treatment to clear field at weekly interval in weed free treatment, and hand weeding was done at 20 days after sowing (DAS) in hand weeding treatment. The trial was laid out in randomized block design with three replications.

Sabitri cv of rice was sown on 7th July 2010, 15th June 2011 at the rate of 30 kg/ha with Pantnagar Zero Till Drill in line. Row to row spacing was kept 20 cm and plant to plant spacing was made continuous. Seeds of *Sesbania aculeata* were also sown at the rate of 15 kg/ha for brown manuring (compost of straw and other remaining in the field) in mentioned plots. Nitrogen, phosphorous and potash fertilizers were applied @ 100: 50:30 kg/ha whereas, nitrogen applied through urea (46%N) and phosphorus through DAP (18%N and 46% P_2O_5) and potash through muriate of potash (60% K_2O). Half dose of nitrogen, full dose of

phosphorous and potash were applied as basal dose and remaining half of nitrogen was applied in two split doses first at active tillering and second at panicle initiation stages in all the treatments. Pre-sowing irrigation was provided before stale-seedbed. Irrigation was applied in the field as per requirement. About 5 cm water was maintained either through deep tube well or by pumping set regularly up to grain filling stage of rice crop. chlorpyriphos (Dursban) @ 2 ml/litre of water was applied before milking stage of the crop to protect it sucking from gundhi bug (*Leptocorisa varicornis*).

Observations were taken on weed density, dry weed weight, weed index and weed control efficiency at 30 and 60 days after sowing from one meter square area. Plants were harvested from the net plot area (15 m^2) and left in the field for 5-7 days for sun drying. Threshing was done on cemented threshing floor manually and the after grains were cleaned by winnowing. The grain yield was recorded at 12% moisture. The grain yield, straw yield, grain straw The index were recorded from the net plot of 15 m^2 areas. Final data were analyzed by standard statistical techniques (MSTAT- C package).

Table 1. Weed density at 30 DAS as influenced by integrated weed management practices in dry direct seeded rice at RARS, Parwanipur, Bara

SN	Treatments	Weed density(no/m^2) 30 DAS					
		Broad leaves		Sedges		Grasses	
		2010	2011	2010	2011	2010	2011
1	Weedy	112.40A (10.22A)	15.10B (3.94A)	40.60B (6.41B)	12.60AB (3.61A)	104.40A (10.15A)	12.76B (3.64A)
2	Weed free	0.00C (0.71D)	0.00B (0.71F)	0.00E (0.71H)	0.00AB (0.71F)	0.00C (0.71F)	0.00B (0.71F)
3	Pendimethalin fb bispyribac	68.60B (7.98B)	11.45C (3.45B)	146.90A (12.14A)	9.08C (3.09B)	62.00B (7.90B)	11.68D (3.48AB)
4	Pendimethalin fb two hand weeding	7.40C (2.51CD)	0.50C (0.99E)	1.30DE (1.33FG)	0.43B (0.96F)	4.80C (2.30E)	3.38C (1.97D)
5	Stale seedbed fb bispyribac	8.90C (2.80C)	1.08B (1.24D)	4.50DE (2.23E)	3.83AB (2.07D)	10.80C (3.35D)	6.88B (2.71C)
6	Stale seedbed fb Pendimethalin fb bispyribac	8.20C (2.49CD)	0.95B (1.20DE)	1.50DE (1.41F)	3.40AB (1.97D)	9.70C (3.19DE)	4.43B (2.22D)
7	Mulch 4t/ha fb bispyribac fb One hand weeding	13.10C (3.34C)	8.03C (2.92C)	6.80D (2.68D)	5.48C (2.44C)	18.80C (4.39C)	10.28DE (3.27B)
8	Stale seedbed fb mulch4t/ha fb bispyribac	56.90B (7.13B)	0.78C (1.13DE)	13.60C (3.75C)	1.64AB (1.45E)	53.10B (7.29B)	3.65B (2.04D)
9	Pendimethalin and Sesbania co-culture fb2,4-D Na salt fb one hand weeding	63.60B (7.41B)	11.05A (3.39B)	15.30C (3.96C)	8.10A (2.92B)	65.10B (8.08B)	11.78A (3.50AB)
10	Pendimethalin fb 2,4-D fb one hand weeding	5.74C (2.32CD)	0.45C 0.97E)	0.50E (1.00GH)	0.30C (0.88F)	4.60C (2.26E)	1.88E (1.53E)
	Mean	34.48 (4.69)	4.94 (1.99)	23.10 (12.14)	4.48 (2.01)	33.33 (4.96)	6.67 (2.50)
	CV%	64.61 (26.47)	18.22 (7.81)	15.61 (3.56)	22.69 (9.85)	36.29 (12.78)	17.27 (7.58)
	F-test	**	**	**	**	**	**
	LSD at 0.05	32.33	1.306	5.232	1.476	17.55	1.67

Results and Discussion

Effect on weed density and dry weed weight

The important weeds infesting in the cropped area were *Cynodon doctylon, Cyperus rotundus, C. iria, Echinochloa crusgalli, E. colonum, Fimbristylis dichotoma, Phyllanthus niruri* etc. Data pertaining to weed density as influenced by integrated weed management practices in its dry direct seeded rice are

presented in Table 1 and Table 2. Irrespective of the years, weed control methods significantly influenced the weed population and dry matter production. There were remarkable variation in weed density and dry weed weight between two years Weed density and weed dry weight were observed higher in 2010 as compared to 2011. The crop experienced severe weed competition in 2010 which might be due to favorable weather condition leading to vigorous weed growth. Behera and Jena (1998) found similar result in DSR. Significantly highest weed population and biomass were found when the weeds were not disturbed during the whole season of crop growth (weedy check i.e. control) while the lowest weed population was observed in weed free treatment. All weed control treatments significantly reduced density and dry weight of weed over weedy check in both years. Among the herbicidal treatments, maximum weed density and biomass were recorded in Pendimethalin followed by Bispyribac and the minimum in pendimethalin followed by 2, 4- D, followed by one hand weeding. It was closely followed by Pendimethalin, followed by two hand weeding. Detail results are presented in Table-1, Table-2, Table-3 and Table-4.

Table 2. Weed density at 60 DAS as influenced by integrated weed management practices in dry direct seeded rice at Parwanipur, Bara

SN	Treatments	Weed density (no/m^2) at 60 DAS					
		Broad leaves		Sedges		Grasses	
		2010	2011	2010	2011	2010	2011
1	Weedy	46.70A (6.74A)	12.18ABC (3.56A)	16.50A (4.11A)	21.80AB (4.72A)	51.00A (7.17A)	18.93B (4.41A)
2	Weed free	0.00B (0.71C)	0.00BC (0.71D)	0.00E (0.71G)	0.00B (0.71G)	0.00F (0.71G)	0.00B (0.71F)
3	Pendimethalin fb bispyribac	44.20A (6.64A)	11.08A (3.39A)	12.10B (3.53B)	16.50A (4.12BC)	32.80C (5.76B)	16.50A (4.12A)
4	Pendimethalin fb two hand weeding	2.80B (1.70BC)	5.05ABC (2.35C)	0.80DE (1.11EFG)	9.90AB (3.21E)	1.11F (1.27F)	3.55B (2.01E)
5	Stale seedbed fb bispyribac	3.80B (2.03BC)	10.13ABC (3.25AB)	1.80DE (1.51DE)	15.30B (3.97BC)	4.60F (2.22E)	9.93B (3.22C)
6	Stale seedbed fb Pendimethalin fb bispyribac	3.10B (1.81BC)	8.60C (3.01B)	1.10DE (1.26EF)	14.20B (3.83CD)	1.90F (1.53F)	9.23B (3.11C)
7	Mulch 4t/ha fb bispyribac fb One hand weeding	8.00B (2.85B)	10.40E (3.30AB)	3.10D (1.87D)	16.38D (4.10BC)	9.30E (3.12D)	12.40D (3.59B)
8	Stale seedbed fb mulch4t/ha fb bispyribac	33.10A (5.57A)	8.50AB (2.99B)	8.30C (2.93C)	12.18AB (3.55DE)	24.60D (5.00C)	6.23B (2.58D)
9	Pendimethalin and Sesbania co-culture fb2,4-D Na salt fb one hand weeding	45.90A (6.50A)	11.78D (3.50A)	12.80B (3.63B)	17.85C (4.28B)	37.30B (6.14B)	16.85C (4.16A)
10	Pendimethalin fb 2,4-D fb one hand weeding	1.80B (1.32C)	3.73E (2.05C)	0.30DE (0.86FG)	6.65D (2.67F)	0.90F (1.17FG)	3.13D (1.89E)
	Mean	18.94 (3.58)	8.14 (2.81)	5.68 (2.15)	13.08 (3.52)	16.35 (3.41)	9.67 (2.98)
	CV%	60.17 (26.22)	16.37 (7.63)	32.79 (14.51)	14.96 (7.42)	18.50 (9.65)	14.41 (6.77)
	F-test	**	**	**	**	**	**
	LSD at 0.05	16.53	1.934	2.702	2.837	4.388	2.023

Data pertaining to weed density significantly influenced by integrated weed management practices in dry direct seeded rice on all types of weeds in both years. The weed density at 30 and 60 days after sowing differed significantly due to integrated weed management practices. The highest number of weeds was recorded in weedy check followed by bispyribac for broad leaves, sedges and grasses in 2010 and 2011 while the lowest weed population were recorded in weed free plot followed by pendimethalin, followed by 2, 4- D, followed by one

hand weeding. The number of weeds was comparatively less in 2011 perhaps due to more rainfall which has suppressed growth of some weeds species. This indicates that one cannot rely on herbicide only for the control of weeds and at least one hand weeding is needed. During both years, the proportion of grassy weed dry weight was higher than other weeds. Grasses persist in all of the principal crops and are a major cause for concern (Mortimer & Richer 2001). It is also reported that the greatest weed pressure and crop-weed competition occurs in aerobic rice and least in transplanted irrigated and rain-fed lowland rice (Datta *et al.* 1996, Moody 1991 and Rao *et al.* 2007). On the other hand, weedy check had significantly the highest weed intensity and dry biomass over all the treatments.

Table 3. Dry weed weight at 30 DAS as influenced by integrated weed management practices in dry direct seeded rice at Parwanipur, Bara

SN	Treatments	Dry weed weight (g/m^2) 30 DAS					
		Broad leaves		Sedges		Grasses	
		2010	2011	2010	2011	2010	2011
1	Weedy	19.72A (4.34a)	2.65B (1.77A)	7.13A (2.96B)	2.21AB (1.65A)	18.32A (4.30A)	2.24B (1.66A)
2	Weed free	0.00C (0.71C)	0.00B (0.71E)	0.0B (0.71F)	0.00AB (0.71F)	0.00C (0.71E)	0.00B (0.71F)
3	Pendimethalin fb bispyribac	10.06B (2.86B)	1.68C (1.48B)	21.55C (4.70A)	1.33C (1.35B)	9.09B (3.09B)	1.71D (1.49B)
4	Pendimethalin fb two hand weeding	0.53C (1.00C)	0.07B (0.75DE)	0.27E (0.88E)	0.23AB (0.85E)	0.64C (1.07DEF)	0.41B (0.95D)
5	Stale seedbed fb bispyribac	1.14C (1.19C)	0.13B (0.79D)	0.21DE (0.84EF)	0.47AB (0.99D)	1.35C (1.36D)	0.61B (1.06C)
6	Stale seedbed fb Pendimethalin fb bispyribac	1.01C (1.48C)	0.08C (0.76DE)	0.09D (0.77EF)	0.06C (0.74F)	0.81C (1.15DE)	0.33E (0.91DE)
7	Mulch 4t/ha fb bispyribac fb One hand weeding	1.92C (1.48C)	1.18C (1.30C)	1.00DE (1.22D)	0.81C (1.14C)	2.76C (1.80C)	1.51E (1.41B)
8	Stale seedbed fb mulch4t/ha fb bispyribac	9.98B (1.20B)	0.14C (0.80D)	2.39E (1.70C)	0.29C (0.89E)	9.32B (3.12B)	0.64CD (1.07C)
9	Pendimethalin and Sesbania co-culture fb2,4-D Na salt fb one hand weeding	8.83B (0.95B)	1.54A (1.42B)	2.13E (1.62C)	1.13A (1.27B)	9.04B (3.08B)	1.64A (1.46B)
10	Pendimethalin fb 2,4-D fb one hand weeding	0.44C (3.07C)	0.03C (0.73DE)	0.08C (0.76EF)	0.03B (0.73F)	0.29C (0.89EF)	0.20C (0.84E)
	Mean	5.36 (1.99)	0.75 (1.05)	3.48 (1.59)	0.65 (1.03)	5.16 (2.06)	0.93 (1.15)
	CV%	70.25 (26.65)	17.78 (4.22)	15.71 (5.80)	23.05 (5.79)	40.28 (12.28)	17.63 (5.19)
	F-test	**	**	**	**	**	**
	LSD at 0.05	5.465	0.1947	0.7827	0.22	30.16	0.2384

Weed control efficiency

Mean data concerning to the effect of the various methods of weeds control verses weedy check on weed control efficiency and weed index showed highly significant difference among them at different growth periods i.e. at 30 and 60 DAS during 2010 and 2011 which have been presented in Table-5. Higher weed control efficiencies resulted in pendimethalin followed by 2, 4- D followed by one hand weeding and pendimethalin followed by two hand weeding and they were at par with weedy check. Experimental site got continuous rainfall in the year 2011, thus, less number of weeds were observed . On the other hand, low weed index resulted in those treatments. Statistically similar weed control efficiencie-were obtained with stale seed bed followed by pendimethalin followed bispyribac. However, weed control in each case was decreased in 2011 as compared to 2010 which might be due to more rainfall favoring growth of plant while the lowest weed index was observed in pendimathalin, followed by 2,4-D followed by one hand weeding and it was immediately followed by treatment

pendimethalin followed by two hand weeding and stale seed bed followed by pendimethalin followed by bispyribac. In each case, the involvement of pendimethalin showed significantly role in controlling weeds and more effectiveness this pre-emergence herbicide in Dry DSR on the basis result. -No doubt weed free check had the highest weed control efficiency and weedy check had the highest weed index.

Table 4. Dry weed weight at 60 DAS as influenced by integrated weed management practices in dry direct seeded rice at Parwanipur, Bara

SN	Treatments	Dry weed weight (g/m^2 60 DAS					
		Broad leaves		Sedges		Grasses	
		2010	2011	2010	2011	2010	2011
1	Weedy	42.46A (6.45A)	11.28B (3.43A)	15.43A (3.97A)	20.22B (4.55A)	47.53A (6.92A)	17.58A (4.25A)
2	Weed free	0.00B (0.71C)	0.00B (0.71F)	0.00D (0.71G)	0.00B (0.71G)	0.00E (0.71G)	0.00A (0.71F)
3	Pendimethalin fb bispyribac	46.13A (6.78A)	11.56B (3.46A)	12.63AB (3.61AB)	17.22AB (4.20AB)	34.23B (5.88B)	17.22A (4.20A)
4	Pendimethalin fb two hand weeding	3.02B (1.75BC)	5.44AB (2.43D)	0.86D (1.14EFG)	10.67AB (3.33E)	1.20E (1.30F)	3.83A (2.08E)
5	Stale seedbed fb bispyribac	4.10B (2.09BC)	10.91B (3.37AB)	1.94D (1.56DE)	16.49B (4.11BC)	4.96DE (2.30E)	10.70A (3.34C)
6	Stale seedbed fb Pendimethalin fb bispyribac	3.24B (1.84BC)	8.98B (3.07BC)	1.15D (1.28DEF)	14.82B (3.91BCD)	1.98E (1.55F)	9.63A (3.18C)
7	Mulch 4t/ha fb bispyribac fb One hand weeding	6.64B (2.61B)	8.63D (3.02C)	2.57D (1.73D)	13.58D (3.74CD)	7.72D (2.85D)	10.29C (3.28C)
8	Stale seedbed fb mulch4t/ha fb bispyribac	33.91A (5.63A)	8.71A (3.03C)	8.50C (2.97C)	12.47A) (3.59DE)	25.20C (5.06C)	6.38A (2.61E)
9	Pendimethalin and Sesbania co-culture fb2,4-D Na salt fb one hand weeding	38.08A (5.93A)	9.77C (3.20ABC)	10.62BC (3.32BC)	14.81AC (3.91BCD)	30.94B (2.60B)	13.98B (3.80B)
10	Pendimethalin fb 2,4-D fb one hand weeding	1.62B (1.28BC)	3.34D (1.96E)	0.27D (0.85FG)	5.96D (2.54F)	0.81E (1.14FG)	2.80C (1.81E)
	Mean	17.92 (3.51)	7.86 (2.77)	5.40 (2.11)	12.62 (3.46)	15.46 (3.33)	9.24 (2.92)
	CV%	56.05 (25.20)	17.31 (7.82)	35.95 (15.12)	15.72 (7.67)	22.79 (10.59)	15.98 (7.20)
	F-test	**	**	**	**	**	**
	LSD at 0.05	14.57	1.974	2.814	2.88	5.11	2.142

Grain and straw yield

Grain yield, straw yield, grain straw ratio and harvest index as influenced by integrated weed management practices are presented in Table-6. Observation of grain yield, straw yield, ration grain and straw ratio, and harvest index recorded significantly different among tested treatments due to integrated weed management practices during both years. The highest grain and straw yield obtained in weed free check closely followed by pendimethalin followed by 2, 4- D followed by one hand weeding, pendimethalin followed by two hand weeding and stale seed bed followed by pendimethalin, followed by Bispyribac and these were statistically at par with each other. Overall, the involvement of pendimethalin followed by manual weeding or other herbicides indicates that pendimethalin seems to be an effective pre-emergence herbicide for weed control in direct seeded rice. The efficacy of Pendimethalin alone (Moody 1991 and Valverde *et al.* 2005) or in combination with hand weeding in controlling weeds in dry direct seeded rice (Dry DSR) was reported highly responsive for controlling weeds (Ramamoorthy *et al.* 1998 and Singh *et al.* 2005). Overall, the grain and straw yield were lower in 2010 than 2011 because of erratic rainfall in occurrence of drought especially during active crop growth stage. However, rainfall pattern of monsoon in the second year was well distributed during crop growth stages of rice resulting in better crop performance. The experimental plots were also heavily infested with gundhi bug (*L. varicornis*) which subsequently reduced yield in 2010.

Table 5. Weed control efficiency and weed index as influenced by different weed management treatments at RARS, Parwanipur 2010/11

SN	Treatments	Weed control efficiency				Weed Index	
		30 DAS		60 DAS			
		2010	2011	2010	2011	2010	2011
1	Weedy	0.00E	16.63D	0.00E	0.00C	89.54A	67.41BC
2	Weed free	100.00A	100.00D	100.00A	100.00D	0.00E	0.00A
3	Pendimethalin fb bispyribac	43.93C	36.23BBC	21.46D	16.79BC	24.01BC	17.51D
4	Pendimethalin fb two hand weeding	94.86A	91.20A	95.99A	65.05A	6.23DE	4.47E
5	Stale seedbed fb bispyribac	90.31AB	82.04C	90.83AB	39.42BC	13.22CD	7.46B
6	Stale seedbed fb Pendimethalin fb bispyribac	92.55AB	87.44E	94.70A	49.01D	13.24CD	4.05E
7	Mulch 4t/ha fb bispyribac fb One hand weeding	84.47B	76.00C	82.28B	33.29BC	15.09CD	8.05BC
8	Stale seedbed fb mulch4t/ha fb bispyribac	15.35D	33.11B	22.49D	11.84BC	32.47B	25.63D
9	Pendimethalin and Sesbania co-culture fb2,4-D Na salt fb one hand weeding	52.66C	51.22BC	42.63C	25.98BC	7.63DE	10.63B
10	Pendimethalin fb 2,4-D fb one hand weeding	95.91A	94.68BC	97.40A	74.40B	3.99DE	2.36CD
	Mean	67	66.85A	64.78	41.58	20.54	14.76
	CV%	9.54	9.79	12.08	16.53	38.25	21.22
	F-test	**	**	**	**	**	**
	LSD at 0.05	9.277	13.25	11.35	9.97	11.4	4.544

Table 6. Grain yield, straw yield, grain straw ratio and harvest index as influenced by different weed management treatments at RARS, Parwanipur during 2010 and 2011

SN	Treatments	Grain Yield(kg/ha)		Straw Yield (kg/ha)		Grain : Straw		Harvest index	
		2010	2011	2010	2011	2010	2011	2010	2011
1	Weedy	537F	2065G	937E	63605E	0.57B	0.32D	36D	32D
2	Weed free	5305A	6369A	6525A	9510A	0.81A	0.67A	45A	40A
3	Pendimethalin fb bispyribac	3938DE	5232E	5147C	8520CD	0.76A	0.61BC	43A	38BC
4	Pendimethalin fb two hand weeding	4997ABC	6351A	6178A	9157AB	0.81A	0.69A	45A	41A
5	Stale seedbed fb bispyribac	4525BCD	5871BCD	5664B	8883BC	0.80A	0.66AB	44A	40A
6	Stale seedbed fb Pendimethalin fb bispyribac	4971ABC	6134ABC	6164A	8935ABC	0.81A	0.69A	45A	41A
7	Mulch 4t/ha fb bispyribac fb One hand weeding	4513BCD	5883CD	5660B	8817BC	0.80A	0.66A	44A	40A

8	Stale seedbed fb mulch4t/ha fb bispyribac	3485E	4719F	4000D	8146D	0.87A	0.58C	47B	37C
9	Pendimethalin and Sesbania co-culture fb2,4-D Na salt fb one hand weeding	4385CD	5671D	5659B	8742BC	0.77A	0.65AB	44A	39AB
10	Pendimethalin fb 2,4-D fb one hand weeding	5161AB	6160AB	6268A	9114AB	0.82A	0.68A	45A	40A
	Mean	4181.65	5440.55	5220	8618.25	0.78	0.62	43.69	38.05
	CV%	10.86	3.66	6.17	4.41	10.57	6.07	6.34	3.76
	F-test	**	**	**	**	**	**	**	**
	LSD at 0.05	659	290.2	467.5	554.9	0.121	0.05	4.02	2.09

Table 7. Economic analysis as influenced by integrated weed management practices in dry direct seeded rice at Parwanipur, Bara

SN	Treatments	Benefit cost ratio and net return/ Rs investment							
		2010				2011			
		Benefit	Cost	B:C	Net return/Rs investment	Benefit	Cost	B:C	Net return/Rs investment
1	Weedy	16099G	53777F	0.30	-0.70	50840G	53577E	0.95	-0.05
2	Weed free	112625A	68689B	1.64	0.64	141645A	69377B	2.04	1.04
3	Pendimethalin fb bispyribac	73877E	64287C	1.15	0.15	117420F	64258C	1.83	0.83
4	Pendimethalin fb two hand weeding	106698C	65087C	1.64	0.64	140756A	65087C	2.16	1.16
5	Stale seedbed fb bispyribac	96164D	61725E	1.56	0.56	130745C	61977D	2.11	1.11
6	Stale seedbed fb Pendimethalin fb bispyribac	105582C	64287C	1.64	0.64	136083B	64287C	2.12	1.12
7	Mulch 4t/ha fb bispyribac fb One hand weeding	95900D	71777A	1.34	0.34	130886C	71777A	1.82	0.82
8	Stale seedbed fb mulch4t/ha fb bispyribac	73699F	68777B	1.07	0.07	106599E	68777B	1.55	0.55
9	Pendimethalin and Sesbania co-culture fb2,4-D Na salt fb one hand weeding	84405E	62687D	1.35	0.35	126533D	62687D	2.02	1.02
10	Pendimethalin fb 2,4-D fb one hand weeding	109487B	61787E	1.77	0.77	136871B	61787D	2.22	1.22
	Mean	87394	64288			116941	61787		
	CV%	0.81	0.79			0.68	0.89		
	F-test	**	**			**	**		
	LSD at 0.05	1213	876.7			1367	977.9		

Economics

A perusal of data on economic analysis of integrated weed management practices in dry direct seeded rice suggested that cost of cultivation was almost the same in both years, but net returns were almost double in the year 2011 than that in 2010 (Table-6) due to more grain and straw production. The highest yield resulted in weed free check followed by pendimethalin followed by two hand weeding and pendimethalin, followed by 2, 4- D followed by one hand weeding. However, the benefit cost ratio and net return per unit investment resulted the highest in pendimethalin followed by 2, 4-D followed by one hand weeding due to saving of labour cost.

Besides the net return per unit investment exceed by stale seed bed followed by bispyribac, and stale seed bed followed by pendimethalin, followed by bispyribac as compared to weed free check. This revealed that amid increasing wage rate and labour scarcity, integrated weed management through pendimethalin 30 EC @1 kg a.i. /ha as pre- emergence herbicide application followed by 2, 4- D sodium salt (80 WP) @ 0.5 kg a.i. /ha followed by one hand weeding or stale seed bed followed by pendimethalin (30 EC) @1 kg a.i. /ha followed by bispyribac (Nominee gold 10%) @25 g a.i. /ha 10% @ 200ml/ha at 20 days of seeding resulted best alternative for manual hand weeding practices giving higher net return per unit investment.

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