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Integrated Weed Management Practices on Productivity and Profitability of Direct Seeded Rice under Aerobic Condition

Piyush Kumar Bhargaw, D. K. Roy, Avinash Kumar, Awdhesh Kumar

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ABSTRACT

At the research farm of RPCAU, Pusa, Samastipur, Bihar, a field experiment was carried out during the 2017 *kharif* season to examine the effects of integrated weed control on the profitability and productivity of direct-seeded rice grown in aerobic conditions. The experiment was laid out in Randomized Block Design having ten treatments with three replications. Both hand weeding and herbicidal treatments, out of all the weed control techniques, had noticeable effects on crop development and yield as well as their superiority to the weedy check. Hand weeding at 20, 40 and 60 days after sowing was found significantly superior over all the integrated weed management practices on productivity and profitability of dry direct seeded rice. Pendimethalin @ 1 kg/ha at 0–2 days after sowing, followed by two hand weedings at 20 and 40 days after sowing, outperformed the other herbicidal treatments in the trial for dry direct seeded rice.

Keywords Bispyribac-Na, Brown manuring, Direct seeded rice, Pendimethalin, Stale seedbed.

INTRODUCTION

Rice holds immense significance globally as it serves as the primary food source for approximately 70% of the world's population. Particularly in developing nations, greater than 50% of the population relies on rice for sustenance, supplying them with essential food, calories, and protein. Additionally, rice is a major consumer of freshwater resources. Being a prominent food crop, rice contributes significantly, accounting for 22% of the world's calorie intake and 17% of protein consumption.

In Asia, specifically, irrigated rice cultivation accounts for over 40% of the global freshwater utilized in agricultural activities. Furthermore, nearly 90% of both the area dedicated to rice cultivation and the rice production itself occurs in Asia. Globally, the total land area used for rice cultivation amounts to 165.25 million hectares, resulting in a production of approximately 501.5 million tons. The average productivity of rice cultivation stands at 3.03 tons per hectare. (STASTISTA –The Statics Portal 2021-22).

Piyush Kumar Bhargaw[1]*, D. K. Roy[2], Avinash Kumar[3], Awdhesh Kumar[4]

[1]Department of Agronomy, [2]Chief Scientist Cum University Professor, Department of Agronomy, [3] Department of Extension Education, [4] Department of SMCA

[1,2,3,4] RPCAU, Pusa, Samastipur 848125, Bihar, India

Email : piyushbhargaw94@gmail.com
*Corresponding author

In India, rice cultivation spans an area of 45.3 million hectares, with an annual production reaching 161.4 million tons. The productivity of rice cultivation in India is recorded at 3.55 tons per hectare (India Stat 2021-22). In Bihar, Rice is cultivated on 3.8 million ha area with the production of 7.9 million ton and the productivity is 2.1 ton/ha (Directorate of economics statistics, Govt of Bihar, 2021-22).

The traditional method of producing irrigated rice is facing challenges due to the diminishing availability and rising cost of water. Several factors contribute to this decline, including abiotic stress such as water and nutrient scarcity, as well as biotic stress caused by weed infestations in the fields. These factors significantly impact rice production, making it unpredictable and resulting in relatively low yields (Singh *et al.* 2010). Weed management in direct seeded rice can be achieved through mechanical, cultural, and chemical methods. In the case of direct seeded rice under non-flooded conditions, aerobic soil conditions promote the germination of various weed species. Early-stage conflict between weeds and the crop intensifies as they emerge simultaneously, leading to a competition for essential growth factors such as light, water, nutrients, and space.

When direct seeded rice is cultivated in aerobic soil with intermittent wetting and drying conditions, it creates favorable conditions for weed germination and growth. As a result, grain yield losses ranging from 50% to 91% can occur due to weed infestations. To address this issue, various approaches such as mechanical weed removal, cultural practices, and judicious use of herbicides can be employed to effectively manage weeds and minimize yield losses in direct seeded rice cultivation (Rao *et al.* 2007).

MATERIALS AND METHODS

The experiment was laid out in Randomized Block Design with ten treatments and three replications. T_1:Pendimethalin @ 1 kg/ha at 0-2 days after sowing followed by Bispyribac-sodium @ 25 g/ha at 20 days after sowing, T_2: Pendimethalin @ 1 kg/ha at 0-2 days after sowing followed by two hand weedings at 20 and 40 days after sowing, T_3: Stale seedbed using Glyphosate @ 1 kg/ha at 10 days before sowing *fb* Bispyribac-Na @ 25 g/ha at 20 days after sowing, T_4: Stale seedbed using Glyphosate @ 1 kg/ha at 10 days before sowing *fb* pendimethalin @ 1 kg/ha at 0-2 days after sowing *fb* Bispyribac Na @ 25 g/ha at 20 days after sowing, T_5: Mulch @ 5 t/ha (by wheat straw) *fb* Bispyribac-Na @ 25 g/ha at 20 days after sowing *fb* one hand weeding at 40 days after sowing, T_6: Stale seedbed using Glyphosate @ 1 kg/ha at 10 days before sowing *fb* mulch @ 5 t/ha (by wheat straw) *fb* Bispyribac-Na @ 25 g/ha at 20 days after sowing, T_7: Pendimethalin @ 1 kg/ha at 0-2 days after sowing and Sesbania co-culture *fb* 2,4-D Na salt @ 0.5 kg/ha at 20 days after sowing *fb* one hand weeding at 40 days after sowing, T_8: Pendimethalin @ 1 kg/ha at 0-2 days after sowing *fb* 2,4-D Na salt @ 0.5 kg/ha at 20 days after sowing *fb* one hand weeding at 40 days after sowing, T_9: Weed free (By hand weedings at 20, 40 and 60 days after sowing) and T_{10}: Weedy check.

Seed of sesbania was sowing in between rows just after seeding of rice for brown manuring and was knock down at 20 days after sowing (DAS) with the help of 2,4-D. Using mulch by wheat straw at just after sowing and also applied stale seedbed technique. The application of pre-emergence herbicide through the use of pendimethalin 0-2 DAS and post-emergence herbicides through the use of Bispyribac sodium (Na) and 2,4-D at 20 DAS. Manual weedings are applied at 20, 40 and 60 DAS.

During the experiment recommended dose of fertilizer viz. 120-60-40 kg/ha N (120 kg/ha), P_2O_5 (60 kg/ha) and K_2O (40 kg/ha) were applied in rice field. Nitrogen was given through urea and DAP and phosphorus as di-ammonium phosphate whereas potassium was given through muriate of potash. At the time of sowing, a basal application of one-third of the nitrogen dose and the full doses of phosphorus and potassium were made, and the remaining two-thirds of the nitrogen dose were applied in two equal splits at the tillering and panicle initiation stages.

Sample plants were randomly selected from net plot area and tagged for recording observations. Growth parameters viz., plant height, number of tiller and accumulations of dry matter were noted at 30, 60 and 90 DAS as well as at harvest stage.

Plant height was measured from randomly selected ten tagged plants in net plot area from the base of the plant to the tip of the upper most leaf at all the

growth stages and expressed as average plant height in centimeter, number of tillers/m^2 and plant dry matter production were recorded at 30, 60, 90 DAS and also at harvest stage from both the corners of net plot area. Randomly selected plants were enclosed within a quadrant measuring 0.50 m^2, which was positioned in the border area. These plants were subsequently uprooted from each designated plot. The collected samples were washed and left to sun dry. Once dried, they were placed in an oven at a temperature of 65°C ± 5°C until a steady weight was attained. The dry matter production was then converted into grams per square meter (g/m^2). The grain yield was determined by weighing the harvested grains from the net plot area in kilograms (kg) and then converting the weight to quintals per hectare (q/ha). The grain weight was adjusted to a moisture content of 0.14 g H_2O/g of fresh weight. The sun-dried straw obtained from the net plot area was also weighed separately on a plot-wise basis in kilograms (kg) and then converted to quintals per hectare (q/ha) at a moisture level of 10% and the harvest index was calculated by using the formula as described by Singh and Stockopf (1971).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (grain yield)}}{\text{Biological yield (grain+straw yield)}} \times 100$$

The economic analysis of the various treatments was conducted by considering the prevailing market prices of inputs and outputs (grain and straw). The gross return (in Rs/ha), net return (in Rs/ha), and benefit-cost ratio were calculated for each treatment, taking into account the purchase price of inputs and the selling price of outputs in the local market. This analysis aimed to assess the profitability and viability of each treatment option.

RESULTS AND DISCUSSION

Effect of integrated weed management practices on growth of direct seeded rice

Evaluating crop growth activities within the context of weed interference is highly valuable. In order to evaluate the growth of dry direct seeded rice, parameters such as plant height, number of tillers, and dry matter production by the rice plants. In the current study, the various weed control practices had a significant impact on all these growth parameters. This emphasizes how crucial efficient weed control is for encouraging dry direct seeded rice to grow and develop at its best (Table 1).

Table 1.. Effect of different weed management practices on plant height, number of tillers and dry matter production of dry direct seeded rice.

Treatments	Plant height (cm)				Number of tillers/m^2				Plant dry matter production (g/m^2)			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1	40.08	73.69	105.38	107.85	133.44	263.42	245.49	219.56	149.72	364.95	677.85	830.00
T_2	45.09	80.79	116.24	118.32	147.55	277.65	260.35	242.94	162.28	376.66	698.75	984.30
T_3	39.18	73.15	102.58	105.45	131.68	259.95	241.88	215.58	149.48	361.88	669.59	805.00
T_4	42.98	77.82	112.83	114.45	144.68	274.80	256.74	239.93	158.94	373.28	695.24	924.00
T_5	43.78	78.65	113.45	115.88	145.09	275.88	257.02	240.70	159.96	373.89	695.88	933.80
T_6	40.82	74.08	108.42	112.78	136.52	262.54	246.32	223.71	150.88	367.59	687.88	839.10
T_7	41.77	74.52	109.69	111.23	139.69	265.35	249.78	226.28	152.78	369.88	690.55	844.00
T_8	44.65	79.57	114.87	116.58	146.65	276.75	258.66	241.91	161.95	374.89	698.04	982.40
T_9	46.87	82.54	117.46	120.45	149.44	279.58	262.18	245.59	165.25	378.29	701.59	986.40
T_{10}	32.58	64.49	78.45	81.22	107.58	219.54	206.54	172.18	139.54	335.65	645.67	548.70
SEm±	**1.01**	**1.01**	**1.33**	**1.51**	**0.96**	**0.96**	**1.34**	**1.29**	**1.14**	**1.14**	**1.19**	**1.4**
CD (p=0.05)	**3.05**	**3.05**	**3.99**	**4.53**	**2.89**	**2.89**	**4.00**	**3.88**	**3.42**	**3.42**	**3.57**	**4.20**

T_1:Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* Bispyribac sodium @ 25 g/ha at 20 DAS,T_2 : Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* two hand weedings at 20 and 40 DAS, T_3 : Stale seedbed using Glyphosate @ 1 kg/ha at 10 days before sowing *fb* Bispyribac sodium @ 25 g/ha at 20 DAS, T_4 : Stale seedbed using Glyphosate @ 1 kg/ha at 10 days before sowing *fb* pendimethalin @ 1 kg/ha at 0-2 DAS *fb* Bispyribac sodium @ 25 g/ha at 20 DAS, T_5 : Mulch @ 5 t/ha (by wheat straw) fb Bispyribac sodium @ 25 g/ha at 20 DAS fb one hand weeding at 40 DAS, T_6 : Stale seedbed using Glyphosate @ 1 kg/ha at 10 days before sowing *fb* mulch @ 5 tonnes/ha (by wheat straw) *fb* Bispyribac sodium @ 25 g/ha at 20 DAS, T_7 : Pendimethalin @ 1 kg/ha at 0-2 DAS and Sesbania co-culture *fb* 2,4-D sodium salt @ 0.5 kg/ha at 20 DAS *fb* one hand weeding at 40 DAS, T_8 : Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* 2,4-D sodium salt @ 0.5 kg/ha at 20 DAS *fb* one hand weeding at 40 DAS, T_9 : Weed free (Manual weedings at 20, 40 and 60 DAS) and T_{10} : Weedy check.

Plant height (cm)

Height of plant is a genetic character generally it is significantly not affected by application of weedicides or fertilizers. The observation of plant height at all the crop growth stages were substantial due to integrated weed management treatments. Weed-free data showed taller plant height while weedy check data showed shorter plant height. At harvest, the weed free, revealed significantly taller plant height which, statistically, was comparable to pendimethalin @ 1 kg/ha at 0-2 DAS *fb* two hand weedings at 20 and 40 days after sowing among herbicidal treatments, pendimethalin @ 1 kg/ha at 0-2 DAS *fb* 2,4-D Na salt @ 0.5 kg/ha at 20 days after sowing *fb* one hand weeding at 40 days after sowing was found taller plant height remained at par with pendimethalin @ 1 kg/ha at 0-2 DAS *fb* 2,4-D Na salt @ 0.5 kg/ha at 20 days after sowing *fb* one hand weeding at 40 days after sowing, mulch @ 5 t/ha (By wheat straw) *fb* Bispyribac Na @ 25 g/ha at 20 days after sowing *fb* one hand weeding at 40 days after sowing and Stale seedbed using Glyphosate @ 1 kg/ha at 10 days before sowing *fb* pendimethalin @ 1 kg/ha at 0-2 days after sowing *fb* Bispyribac @ 25 g/ha at 20 DAS. The taller plant height of the specific treatments possibly because better nutrient consumption, accelerated cell development and meristematic tissue enlargement under least weed growth environment. This finding is in conformity with the findings of Mahajan and Chauhan (2015).

No. of tillers/m^2

Total number of tillers/m^2 recorded at 30, 60, 90 DAS and at harvest was significantly affected by different treatments. Total number of tillers/m^2 were observed to increase up to 60 DAS and thereafter a declining trend was received towards harvest. Among weed management practices, Weed free was recorded maximum number of tillers/m^2 which was comparable with pendimethalin at 0-2 days after sowing *fb* two hand weedings at 20 and 40 days after sowing and pendimethalin @ 1 kg/ha at 0-2 days after sowing *fb* 2,4-D sodium salt at 20 DAS *fb* one hand weeding at 40 days after sowing at all the crop growth stages. It was due to better control of dominant weeds without any phyto-toxicity on rice crops deliver superior environment for production of more number of tillers/m^2. The observed lowest number of tillers in the weedy check plot can be attributed to intense competition for nutrients between the crops and weeds. This intense competition negatively impacted the tiller production capacity of the rice plants. The weeds likely consumed a significant portion of the nutrients, limiting their availability for the rice plants and subsequently resulting in a reduced number of tillers. Effective weed management practices are crucial to mitigate this competition and promote optimal tiller production in rice crops. These results are in settlement with those of Sharma *et al.* (2017).

Dry matter production (g/m^2)

Regardless of the treatment applied, there was a progressive increase in plant dry matter production of direct seeding rice under aerobic condition as the crop advanced towards maturity. This indicates that as the rice plants grew and developed, they exhibited an increase in biomass accumulation. This trend highlights the natural growth pattern of direct seeding rice under aerobic condition, wherein the plants gradually accumulate more dry matter as they approach maturity. The overall dry matter production can be considered as an indicator of the crop's vigor and biomass production during its growth cycle. The peak rate of crop growth was observed between 60 and 90 DAS. Weed free produced maximum production of dry matter and it was statistically at par with pendimethilin *fb* manual weedings at 20 and 40 days after sowing and pendimethalin at one kg/ha at pre-emergence followed by 2,4-D sodium salt at 0.5 kg/ha at post-emergence followed by one manual weeding at fourty days after sowing at all the crop growth stages. Among the different herbicidal treatments, pendimethalin @ 1.0 kg/ha at 0-2 days after sowing *fb* two hand weedings at 20 and 40 days after sowing, produced highest dry matter production (162.28, 376.66, 698.75 and 984.30 g/m^2) at 30, 60, 90 DAS and at harvest, respectively. It was closely followed by pendimethalin @ 1 kg/ha at 0-2 days after sowing *fb* 2,4-D Na salt @ 0.5 kg/ha at 20 days after sowing *fb* one hand weeding at 40 days after sowing (161.35, 374.89, 698.04 and 982.40 g/m^2) at 30, 60, 90 DAS and at harvest, mulch @ 5 t/ha *fb* Bispyribac Na @ 25 g/ha at 20 days after sowing *fb* one hand

weeding at 40 days after sowing (159.96, 373.89, 695.88 and 933.80 g/m^2) at 30, 60, 90 DAS and at harvest and Stale seedbed using Glyphosate @ 1 kg/ha at 10 days before sowing *fb* pendimethalin @ 1 kg/ha at 0-2 days after sowing *fb* Bispyribac @ 25 g/ha at 20 DAS (158.94, 373.28, 695.24 and 924 g/m^2) at 30, 60, 90 DAS and at harvest, respectively. The higher production of dry matter in certain treatments to be responsible for a higher Leaf Area Index (LAI), which leads to greater photosynthate production. Treatments with better weed control and reduced weed interference allowed the rice plants to have a higher LAI, resulting in increased photosynthesis and subsequent dry matter production. In particular, the weed-free treatment showed significantly higher dry matter production at harvest in contrast to alternative treatments. This can be attributed to the absence of weed competition, allowing the rice plants to utilize resources more efficiently and allocate more energy towards growth and biomass accumulation. Conversely, the weedy check plot exhibited the least amount of dry matter produced. This was primarily due to severe weed infestation, which caused poor tillering and an overall reduction in growth parameters. The weeds competed with the rice plants for materials like nutrients, water, and light, resulting in compromised growth and reduced dry matter production. These findings highlight the importance of effective weed management in maximizing dry matter production and overall crop growth in direct seeded rice. This finding is in conformity with Ramachandiran and Balasubramanian (2012).

Table 2. Effect of different weed management practices on grain yield (q/ha), straw yield (q/ha) and harvest index (%) of dry direct seeded rice.

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
T_1	32.55	50.45	39.22
T_2	37.35	58.05	39.16
T_3	31.87	48.63	39.59
T_4	34.02	51.38	39.84
T_5	34.89	52.49	39.93
T_6	32.93	50.98	39.23
T_7	33.35	51.05	39.51
T_8	35.26	53.68	39.76
T_9	38.79	60.05	39.13
T_{10}	21.25	33.62	38.73
SEm±	**1.22**	**1.32**	**0.80**
CD (p=0.05)	**3.58**	**3.94**	**NS**

T_1: Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* Bispyribac sodium @ 25 g/ha at 20 DAS, T_2 : Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* two hand weedings at 20 and 40 DAS, T_3 : Stale seedbed using Glyphosate @ 1 kg/ha at 10 days before sowing *fb* Bispyribac sodium @ 25 g/ha at 20 DAS, T_4 : Stale seedbed using Glyphosate @ 1 kg/ha at 10 days before sowing *fb* pendimethalin @ 1 kg/ha at 0-2 DAS *fb* Bispyribac sodium @ 25 g/ha at 20 DAS, T_5 : Mulch @ 5 tonnes/ha *fb* Bispyribac sodium @ 25 g/ha at 20 DAS *fb* one hand weeding at 40 DAS, T_6 : Stale seedbed using Glyphosate @ 1 kg/ha at 10 days before sowing *fb* mulch @ 5 tonnes/ha (by wheat straw) *fb* Bispyribac sodium @ 25 g/ha at 20 DAS, T_7 : Pendimethalin @ 1 kg/ha at 0-2 DAS and Sesbania co-culture *fb* 2,4-D sodium salt @ 0.5 kg/ha at 20 DAS *fb* one hand weeding at 40 DAS, T_8 : Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* 2,4-D sodium salt @ 0.5 kg/ha at 20 DAS *fb* one hand weeding at 40 DAS, T_9 : Weed free (Manual weedings at 20, 40 and 60 DAS) and T_{10} : Weedy check.

Grain and straw yield (q/ha)

Grain and straw yields of dry direct seeded rice were influenced significantly by different weed control treatments (Table 2). The weed free had significantly higher grain (38.79 q/ha) and straw yield (60.05 q/ha). The weedy check treatment resulted significantly lowest grain yield (21.25 q/ha) and straw yield (33.62 q/ha) among all the treatments. In herbicidal treatment, pendimethalin at 0-2 days after sowing *fb* two manual weedings at 20 and 40 DAS was significantly superior over all other treatments, recorded grain yield (37.35 q/ha) and straw yield (58.05 q/ha). The treatment manual weedings at 20, 40 and 60 DAS and pendimethalin at 1 kg/ha at 0-2 DAS followed by two hand weedings at 20 and 40 DAS yielded 182.54% and 175.76% more than the weedy check, respectively. Mukherjee and Maity (2008) revealed similar findings of manual weeding yielding the maximum grain and straw yield of upland rice. Among the chemical weed control methods, considerably higher grain yield (37.35 q/ha) was obtained with application of pendimethalin at 1.0 kg/ha at 0-2 DAS *fb* manual weedings at 20 and 40 DAS, was statistically at par with pendimethalin @ 1 kg/ha at 0-2 days after sowing *fb* 2,4-D sodium salt at 0.5 kg/ha at twenty days after sowing *fb* one hand weeding at 40 days after sowing (35.16 q/ha), mulch @ 5 t/ha *fb* Bispyribac Na @ 25 g/ha at 20 days after sowing *fb* one hand weeding at 40 days after sowing (34.89 q/ha) and Stale seedbed using Glyphosate @ 1 kg/ha at 10 days before sowing *fb* pendimethalin @ 1 kg/ha

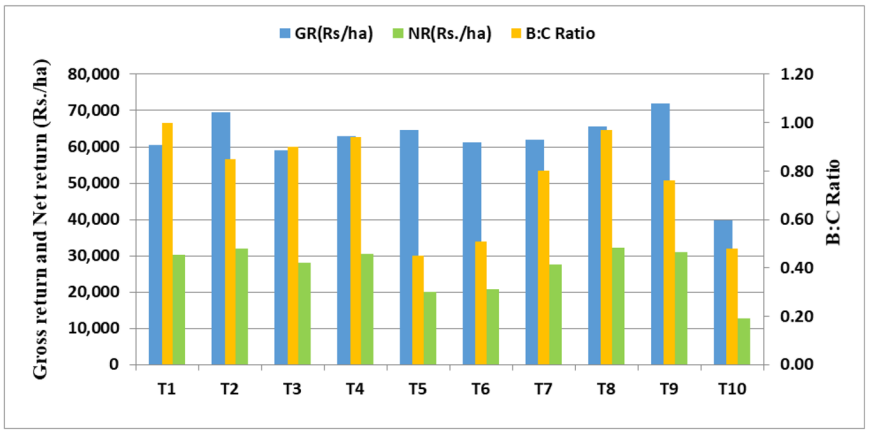

Fig. 1. Effect of integrated weed management practices on profitability of direct seeded rice under aerobic condition.

T_1: Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* Bispyribac sodium @ 25 g/ha at 20 DAS, T_2 : Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* two hand weedings at 20 and 40 DAS, T_3 : Stale seedbed using Glyphosate @ 1 kg/ha at 10 Days before sowing fb Bispyribac sodium @ 25 g/ha at 20 DAS, T_4 : Stale seedbed using Glyphosate @ 1 kg/ha at 10 days before sowing *fb* pendimethalin @ 1 kg/ha at 0-2 DAS *fb* Bispyribac sodium @ 25 g/ha at 20 DAS, T_5 : Mulch @ 5 tonnes/ha *fb* Bispyribac sodium @ 25 g/ha at 20 DAS *fb* one hand weeding at 40 DAS, T_6 : Stale seedbed using Glyphosate @ 1 kg/ha at 10 days before sowing *fb* Mulch @ 5 tonnes/ha (by wheat straw) *fb* Bispyribac sodium @ 25 g/ha at 20 DAS, T_7 : Pendimethalin @ 1 kg/ha at 0-2 DAS and Sesbania co-culture *fb* 2,4-D sodium salt @ 0.5 kg/ha at 20 DAS *fb* one hand weeding at 40 DAS, T_8 : Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* 2,4-D sodium salt @ 0.5 kg/ha at 20 DAS *fb* one hand weeding at 40 DAS, T_9 : Weed free (Manual weedings at 20, 40 and 60 DAS) and T_{10} : Weedy check.

at 0-2 days after sowing *fb* Bispyribac Na @ 25 g/ha at 20 days after sowing (34.02 q/ha) in case of grain yield. The better grain yield with these treatments is due to reduced weed density, weed biomass and better weed control efficiency along with enhancement in yield attributes like number of panicles/m^2, panicles length, number of grains/panicle and 1000-grain weight. This is consistent with the findings of Gogoi *et al.* (2010) and Singh *et al.* (2015). Different weed management practices observed non-significantly effect on harvest index. Harvest index is the key factor in determining the success of yield. The highest harvest index value of 39.93%, were obtained with the treatment T_5- Mulch @ 5 t/ha (By wheat straw) *fb* Bispyribac-Na @ 25 g/ha at 20 DAS *fb* one hand weeding at 40 DAS and lowest harvest index value 38.73%, were obtained under weedy check. The higher values of the harvest index of the concerned treatment were because of better grain yield than weedy check treatment.

Gross rerurn, net return and benefit-cost ratio

Different weed management strategies were found to have a substantial effect on gross and net return, as well as the benefit-cost ratio (Fig. 1). Weed free provided the highest gross return (Rs 71,825/ha), which was statistically equivalent to pendimethalin at 1 kg/ha *fb* two manual weedings at 20 and 40 DAS (Rs 69,503/ha). In terms of net return pendimethalin at 1 kg/ha followed by 2,4-D sodium salt at 0.5 kg/ha at twenty days after sowing followed by one hand weeding at fourty days after sowing had the maximum net return to its credit (Rs 32,244/ha) which was equivalent with pendimethalin followed by two manual weedings at 20 and 40 days after sowing (Rs. 31,997/ha), hand weedings at 20,40 and 60 DAS (Rs 31,080/ha), Stale seedbed at ten days before sowing followed by pendimethalin followed by Bispyribac sodium (Rs 30,482/ha) and pendimethalin followed by Bispyribac sodium (Rs 30,229/ha). In terms of benefit-cost ratio, pendimethalin at pre-emergence followed by Bispyribac sodium at post-emergence had recorded maximum benefit-cost ratio of 1.0, which was statistically at par with pendimethalin at pre-emergence followed by 2,4-D sodium salt at post-emergence followed by one hand weeding at fourty days after sowing (0.97), Stale seedbed at ten

days before sowing followed by pendimethalin at 0-2 DAS followed by Bispyribac sodium at 20 days after sowing (0.94) and stale Seedbed at ten days before sowing followed by bispyribac sodium at twenty days after sowing (0.90). It is a fact that better grain and straw yields, as well as decreased cultivation costs, all result in a better net return. Thus, the economic side largely stays a mirror of economic yield, and the treatments identified superior in economic yields were also superior in return and benefit-cost ratio. The findings of this study in terms of economic aspects are consistent with those published by Devi and Sumathi (2011).

Finally, it may be concluded that, the maximum crop growth and yield of dry direct seeded rice were recorded by weed free (By hand weedings at 20, 40 and 60 DAS). It was statistically equivalent to pendimethalin @ 1 kg/ha at 0-2 DAS *fb* two hand weedings at 20 and 40 DAS and pendimethalin at 1.0 kg/ha followed by 2,4-D sodium salt at 0.5 kg/ha at 20 DAS followed by one hand weeding at 40 DAS. Among herbicidal treatments, the maximum crop growth, productivity and profitability were recorded by pendimethalin @ 1 kg/ha at 0-2 DAS *fb* two hand weedings at 20 and 40 DAS which was statistically at par with pendimethalin @ 1 kg/ha at 0-2 DAS *fb* 2,4-D Na salt @ 0.5 kg/ha at 20 DAS *fb* one hand weeding at 40 DAS, mulch @ 5 t/ha (By wheat straw) *fb* Bispyribac Na @ 25 g/ha at 20 DAS *fb* one hand weeding at 40 DAS and Stale seedbed using Glyphosate @ 1 kg/ha at 10 DBS *fb* pendimethalin @ 1 kg/ha at 0-2 DAS *fb* Bispyribac Na @ 25 g/ha at 20 DAS.

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