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Yield and economics of aerobic direct seeded upland rice (*Oryza sativa* L.) as affected by different weed control measures under rice-wheat (*Triticum aestivum* L.) system

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ABSTRACT

Field trial/ on farm trials (OFT) was carried out on farmer's field at Atnauwan, Hasanchak and Agwanpur associated with the Krishi Vigyan Kendra, Barh, Patna, Bihar in the two consecutive year 2014-15 and 2015-16 during the kharif season. The trial was conducted in randomized complete block design replicated 04 times (Four no of farmers)with 07 treatments. The treatments were composed of application of 2,4-D @ 1.0 kg a. i. ha^{-1}at 25 days after sowing, Pendimethalin1.00 kg a.i. ha^{-1} at 1-3 days after sowing, Pyrazosulfuron@ 200 g ha^{-1}at 20-25 days after sowing, Bispyribac Sodium @ 200 g ha^{-1}at 20-25 days after aftersowing,combined applicationofPyrazosulfuron@ 200 g ha^{-1} + Bispyribac Sodium @ 200 g at 20-25 days after sowing, weed free (Farmer practices) and weedy check. During the trial period various growth and yield attributes were recorded. Grassy weeds, broad leaf weeds and sedges were observed during the crop growth period. Combined application of Pyrazosulfuron @ 200 g ha^{-1}+ Bispyribac Sodium @ 200 g at 20-25 days after sowing proved most efficient in controlling weeds with 95.9 % weed control efficiency (WCE). Maximum plant height (cm), more number of effective tillers/m^{2}higher panicle length (cm), less weed dry weight both grassy and broad leaf weight (g), highest grain (65.0 q ha^{-1}) and straw(110.0 q ha^{-1})yield were recorded under weed free plot (Farmer practices). Among the herbicides treatments, combined application of Pyrazosulfuron @ 200g ha^{-1}+ Bispyribac Sodium @ 200 g ha^{-1}at 25 days after sowingfound highest grain yield (62.2 q ha^{-1}), net return (Rs. 65,862.0 ha^{-1}) and B:C ratio (2.8) as compared to other herbicides treatments. The significantly lowest growth parameters, yield attributes, yield economics were recorded under weedy check.

***Keywords*:** Bispyribac sodium, direct seeded rice, economics, pyrazosulfuron, yield

Rice is the leading cereal crop in the world. It is an important staple food which is highly produced and consumed in Asia of the world's rice production (FAO, 2014).Among the cereals, total area under rice cultivation in India is 43.19 million hectares with the production of 117.47 million tonnes in 2019-2020 (Anonymous, 2020).,production of rice in India is 157 million tonnesand India holds second rank in total production after China in the world and its share about 21.2 per cent in the world during 2015 (Wadhwa, 2018). Rice production system are undergoing numerous changes in establishment methods of rice cultivation and one of such alternative is direct dry or wet seeding of rice. In many Asian countries, farmers recently started to change their rice cultivation practices from the conventional transplanted rice to dry seeded rice (DSR). Puddling or traditional rice planting method is a labour, water and energy intensive (Mahajan *et al.*, 2012, Chauhan *et al.*, 2012). Direct seeding rice allow such advantages as quick and easier planting which is less labour intensive and drudgery, rice mature early by10 days, high water use efficient and tolerance of water under low moisture, decline methane emission as compared with conventional transplanting and more profit in areas with an assured water supply (Balasubrmanian *et al.*,2002).

Dry Seeded Rice (DSR) is a process of establishment of the crop from the seeds sown in non-puddled and unsaturated/ aerobic soil in contrast; the seedlings from nursery are transplanted in the puddle soil in transplanted flooded rice. In Direct Seeded Rice system, dry rice seeds are sown with or without tillage and irrigation is applied periodically to maintain soil moisture at field capacity. Direct Seeded Rice (DSR)is a novel method of sowing with having water saving of up to 18 per cent and aids in quick establishment and early harvest than transplanted rice and consequently facilitates timely wheat seeding (Tabbal *et al.*, 2002; Singh *et al.*, 2007).

Weeds are the one of the factor in aerobic DSR which antecedent a subsequent losses the yield in rice crop. The adoption and sustainability of the aerobic rice systems is threatened by heavy weed infestation (Chauhan, 2012). In DSR, weed emerges simultaneously with crop seedlings and grows more quickly in moist soil than in puddle transplanted rice. The grain yield losses of 50-91per cent were reported due to weed infestationandYield losses can go as high as 90 per cent if control measures are not taken. Timely weed control is therefore crucial in improving the productivity and profitability of DSR (Rao *et al.*, 2007; Khaliq and

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Matloob, 2011; Chauhan and Johnson, 2011). In this connection, for the weed control in DSR rice crop many Pre and Post post and preemergence herbicides is being tested and are available in the marke nd use of herbicides of different composition is desirable to reduce the problem of residue build-up, shift in weed problem Therefore, experiment on Yield and economics of Aerobic Direct Seeded upland Rice (*Oryza sativa* L.) as affected by different weed control measures under rice-wheat (*Triticumaestivum* L.) system.

MATERIALS AND METHODS

Field experiment (on farm trial) was conducted at 3 different villages *viz.*, Atnauwan, Hasanchak and Agwanpur associated with the Krishi Vigyan Kendra, in rice-wheat cropping system, Barh, Patna, Bihar Agricultural University, Bhagalpur in the two consecutive year 2014-15 and 2015-16 during the *kharif* season. Two farmers were selected in each village.The trial ware carried out in Randomized Complete Block Design (RCBD) with seven treatments replicated with 04times (Four number of farmers). The seven treatments combination in which application of pre and post emergence herbicide. The treatments was allocated for each of seven weed control methods *viz.*, T_1-application of 2,4-D @ 1.0 kg a.i.ha^{-1} at 25 days after sowing, T_2-application of Pendimethalin @ 1.00 kg a.i. ha^{-1} at 1-3 days after sowing), T_3-application of Pyrazosulfuron (sathi 10% WP) @ 200g ha^{-1}at 20-25 days after sowing, T_4-application of Bispyribac sodium (Nominee gold) @ 200 g ha^{-1} @ 20-25 days after sowing and T_5-application of Pyrazosulfuron (sathi 10% WP) @ 200g ha-1+ Bispyribac sodium (Nominee gold) @ 200 g ha^{-1} @ 20-25 days after sowing.During *kharif*, rice variety Rajendra Mansouri-1 (RM-1)was sown direct seeded during the second fortnight of May and harvested in the second fortnight of October in both the years. The recommended quantity of Farmyard manure@ 10 tonnes ha^{-1} was applied to rice during the May (*Kharif*) before monsoon and sowing of seed. Fertilizer was applied @ 120 kg N, 60 kg P_2O_5 and 60 kg K_2O and 25 kg $ZnS0_4$ ha^{-1}. The recommended dose of fertilizer was supplied to crops in the form of Urea, DAP and MOP, respectively. Irrigation was given as per the need of rice crop at proper time properly there was not limiting in both the year. Need based intercultural and plant protection measures were adopted for the crops. The soil texture at the test sites was clay loam. The average values as well as ranges of soil properties in experimental fields were neutral having pH 6.5-7.5, moderately saline, electrical conductivity EC 1.11-1.27 dsm^{-1}, low Nitrogen (N) 229 kg ha^{-1}, low Phosphorus (P) 10.6 kg ha^{-1} and low Potassium (k) 147.40 kg ha^{-1}. Soil available N, P, K and other parameters were estimated as per standards procedure. Herbicides was applied with the help of hand operated sprayer mounted with flat fan nozzle at a spray volume of 300l ha^{-1}. Observations of density of broad leaf and grassy was recorded by quadrate (0.25 m length ×0.25 m width) selected place randomly at two representative sites in each plot at 30, 60 and 90 DAS. BLW and grassy weeds were collected from the field and recorded the freshweed dry weight. After taken the fresh weight, weed samples were sun dried and before oven dried at 65°C until constant weight was obtained.Weed control efficiency (WCE) of different treatments were determind based on reduction in dry weight of weeds weighed in treated plots over the weedy check and expressed as percentage**.** Formula of Mani *et al*. (1973) was adopted for computing the weed control efficiency. WCE (%) = (WDC- WDT) x 100/ WDC x 100, Where, WDC = Weed dry weight in control plot (g/m^{-2}), WDT = Weed dry weight in treated plot (g/m^{-22}). The gross plot (4 x 3.5m) had 10 rows, out of which only 6 rows were harvested for net plot. Out of 3.5 m row length 0.5 m length from both sides were left as border, and the harvesting of net plot of (3.5 x 2.5 m) 8 m² area was done manually. Then the weight of grain harvested from the net plot was recorded and converted into q ha^{-1}.The data were analyzed of ANOVA using CPCS software and the least significant difference (LSD) values at 5% level of significance were calculated and used to test significant difference between treatment means.

RESULTS AND DISCUSSION

Weed dry weight (g)

Weeds dry matterd epends on growth and weed population recorded under the different herbicidal treatments. Weed control measures in response to different herbicides resulted in significant reduction in dry matter of grasses, broad leaf and sedges as than the weedy check at 30, 60 and 90 days after sowing (DAS). This significant deductionreductionin weed dry weight of grasses, broadleaf and sedges was the fact that of chemical weed control measures (Table 1). Dry matter of grassy (5.1 and 6.0 g) and broadleaf weeds (4.2 and 4.8 g) and sedges (4.5 and 2.00 g), was recorded lowest at 60 and 90 DAS, respectively, with application of Pyrazosulfuron @ 200g ha^{-1}+ bispyribac sodium @ 200 g ha^{-1}@ 20-25 days after sowing. These treatments were found superior with weedy check with significant reduction in dry weight of weeds These treatments were found for the deduction in dry matter of grassy, broadleaf and sedges weeds than the weedy check. Singh *et al.*, (2017) showed similar results revealed that among the chemical control measures, Bispyribac sodium + Pyrazosulfuron (100 ml+100ml) was highly effective in controlling weeds as it recorded lowest density and

Table 1: Effect of different herbicide control measures on dry matter of grassy weeds, broadleaf weeds and sedges in direct seeded aerobic upland rice (*Oryza sativa* L.) (pooled data of two year).

Treatments	Dry matter of Grassy weeds (g m^{-2})			Dry matter of BLW weeds (g m^{-2})			Dry matter of sedges (g m^{-2})		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
2,4-D @ 1.0 kg a.i. ha^{-1}	30.8	22.7	6.2	18.6	6.6	6.3	10.3	6.2	5.3
Pendimethalin @ 1.0 kg a.i. ha^{-1}	6.4	24.9	30.3	7.0	20.4	24.4	8.1	5.1	8.7
Pyrazosulfuron 10% WP @ 200g ha^{-1}	18.4	15.3	17.3	26.8	16.8	18.8	10.0	4.2	6.9
Bispyribac sodium @ 200 g ha^{-1}	22.2	12.3	14.0	29.0	9.0	9.3	11.8	7.4	14.7
Pyrazosulfuron 10% WP @ 200gha^{-1} + Bispyribac sodium @ 200 g ha^{-1}	12.4	5.1	6.0	16.2	4.2	4.8	9.2	4.5	2.0
Weed free (Farmer practices)	3.1	20.0	20.5	31.25	20.85	20.0	31.0	20.80	20.0
Weedy check	120	71.8	98.6	128.0	147.0	198.0	14.0	18.0	16.4
SEd(±)	**02.98**	**03.69**	**04.50**	**04.81**	**04.478**	**03.422**	**02.71**	**01.68**	**03.5**
LSD (0.05)	**2.98.6**	**1.81.5**	**1.52.1**	**12.41**	**14.34**	**1.29.45**	**2.26.5**	**15.8**	**10..46**

Table 2: Effect of different herbicide control measures on yield attributes, total weed density and weed control efficiency in direct seeded aerobic upland rice (*Oryza sativa L.*) (pooled data of two year).

Treatments	Plant height (cm)	Effective tillers /m^{-2}	Panicle length (cm)	1000 grain weight (g)	Total weed density & dry matter (g m^{-2})	Weed con-trol Effi-ciency (%)
					90 DAS	90 DAS
2,4-D @ 1.0 kg a.i. ha^{-1}	71.1	339.0	15.4	22.3	12.3 (35.8)	88.7
Pendimethalin @ 1.0 kg a.i. ha^{-1}	75.5	360.6	18.2	23.3	16.4 (71.4)	77.4
Pyrazosulfuron 10% WP @ 200g ha^{-1}	80.4	416.6	20.2	23.0	13.2 (43.0)	86.4
Bispyribac sodium @ 200 g ha^{-1}	76.9	390.4	19.0	24.0	12.0 (38.0)	88.0
Pyrazosulfuron 10% WP @ 200gha-1+ Bispyribac sodium @ 200 g ha^{-1}	82.8	438.4	21.2	24.5	7.0 (12.8)	95.9
Weed free (Farmer practices)	90.0	495.0	22.1	21.0	3.0 (0.5)	100.0
Weedy check	50.5	185.2	8.3	25.0	63.0 (317.0)	0.0
SE d(±)	**4.3**	**9.3**	**1.6**	**0.4**		—
LSD (0.05)	**14.0**	**28.0**	**4.9**	**1.2**	—	—

Table 3: Effect of different herbicide control measures on yield and economics in direct seeded aerobic upland rice (*Oryza sativa* L.) (pooled data of two year).

Treatments	Grain Yield (q ha^{-1})	Straw Yield (q ha^{-1})	Cost of Cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
2,4-D @ 1.0 kg a.i. ha^{-1}	54.3	81.1	35,530	88,343.5	52,813.5	2.5
Pendimethalin @ 1.0 kg a.i. ha^{-1}	57.1	87.8	34,400	93,113	58,713.0	2.7
Pyrazosulfuron 10% WP @ 200g ha^{-1}	60.5	94.9	35,650	98,816.5	63,166.5	2.8
Bispyribac sodium @ 200 g ha^{-1}	58.5	95.1	35,680	95,833.5	60,153.5	2.7
Pyrazosulfuron 10% WP @ 200gha-1+ Bispyribac sodium @ 200 g ha^{-1}	62.2	99.2	35,870	1,01,732	65,862.0	2.8
Weed free (Farmer practices)	65.0	110.0	42,850	1,06,850	64,000.0	2.5
Weedy check	21.8	38.0	28,500	35,930	7,430.0	1.3
SEd(±)	**1.3**	**1.7**	**—**	**1410.0**	**944.0**	**0.04**
LSD (0.05)	**4.1**	**5.4**	**—**	**4231.0**	**2832.0**	**0.2**

dry weight of weed 5.67 m^{-2} and 8.13 g m^{-2} respectively. Based on the field observation taken from the different treatments, the dry matter production of sedges were found to increase up to 90 days stage of crop growth except in combined application of Pyrazosulfuron @ 200g ha^{-1}+ bispyribac sodium @ 200 g ha^{-1}and Pyrazosulfuron @ 200g ha^{-1}, where most of the sedges were controlled after its application. Generally, the dry matter of broad leaf weeds increased up to 90 DAS except in case of 2,4-D @ 1.0 kg a.i. ha^{-1}which were found highly effective for controlling broad leaf weeds where most of the control of broad leaf weeds was noticed. Pendimethalin @ 1.00 kg a.i. ha^{-1} react both in way pre-emergence, that is before weed seedlings emergence, and early post-emergence. This was found highly effective for prevents weeds from emerging up to 30 DAS and later particularly inhibits root and shoot growth of grasses, broad leaf weeds and sedges.

Yield attributes and WCE (%)

Yield attributing observation was significantly affected by the application of different herbicidal treatments (Table 2). Weed free (Farmers practices) recorded significantly highest plant height (cm), highest effective tillers /m^2, highest panicles length (cm) and 1000 grain weight than the other treatments. Among herbicide treatments, Pyrazosulfuron @ 200g ha^{-1}+ bispyribac sodium @ 200 g ha^{-1} recorded highest plant height (cm), highest effective tillers /m^2, highest panicles length (cm) and 1000 grain weight compared to other treatments. Reducing in the weed population become stable environment for direct seeded aerobic rice, enhanced the uptake of essential nutrients and translocation of photosynthates from the source to sink which influenced the yield attributes positively. Weedy check recorded the lowest plant height (cm), lowest effective tillers /m^2, lowest panicles length (cm) and lowest 1000 grain weight. This was might be due to severe weed competition exerted by different weeds for light, space and nutrients throughout the crop growth period. Similar results were found by Singh *et al.* (2017) reported that highest number of effective tillers m^{-2} and grains spike^{-1} were recorded when weeds were controlled by two hand weedings at 20 and 40 DAT and were at par with application of Bispyribac sodium + Pyrazosulfuron. Weed control efficiency (WCE) (%) was calculated based on dry matter accumulation of weed at (90 DAS) basis due to weed control measures (Table 2). Among the herbicidal treatments highest WCE was observed under combined application of Pyrazosulfuron @ 200g ha^{-1}+ bispyribac sodium @ 200 g ha^{-1}and Pyrazosulfuron @ 200g ha^{-1} followed by 2,4-D @ 1.0 kg a.i. ha^{-1}, Bispyribac sodium @ 200 g ha^{-1}, Pyrazosulfuron @ 200g ha^{-1} and Pendimethalin @ 1.00 kg a.i. ha^{-1}. The weed free treatments recorded highest weed control efficiency (WCE) because of no weeds while the lowest WCE ware found under the weedy check (Table 2).

Grain and straw yield of rice

Yield of aerobic DSR is significantly affected by the weed control practices which reflecting the grain yield increased from 21.80 to 65.00 q ha^{-1} (Table 3). The increase ranged from 60.0% - 66.0% over weedy check/ control. Among the herbicidal treatments, weedfree situation recorded the highest grain yield of 65q ha^{-1}. This was due toweed-free environment maintained by the manual removal ofweeds. Among the different herbicides tested, combined application of pyrazosulfuron (sathi 10% WP) @ 200g ha^{-1}+

bispyribacsodium (Nominee gold) @ 200 g ha^{-1}@ 20-25 days after sowing gave the significant highest paddy yield (62.2 q ha^{-1}) than Pendimethalin (57.1 q ha^{-1}) and 2,4-D (54.3 q ha^{-1}) which was at par with application of Pyrazosulfuron (60.5 q ha^{-1}) and Bispyribac sodium (58.5 q ha^{-1}) @ 20-25 days after sowing while the significant lowest grain yield was observed with application of 2,4-D (54.29 q ha^{-1}) and Pendimethalin (57.13 q ha^{-1}). This was might be due to good control of all weeds and higher yield attributing characters and highest weed control efficiency. Similar results was reported by Iqbal *et al.*, 2017, by their study they reported that twice application of Bispyribac sodium applied at 21 and 40 days after sowing @ 250 ml ha^{-1} or 200 g ha^{-1} helps to achieve higher paddy yield. Weedy check recorded the lowest grain yield (21.8 q ha^{-1}). Straw yield was also highest with combine application Pyrazosulfuron (Sathi 10% WP) @ 200g ha^{-1}+ Bispyribac Sodium (Nominee gold) @ 200g ha^{-1}at 20-25 days after sowing than all other treatments. Similarly, lower straw yield ware found with weedy check due to the highest competition of crop growth factors.

Economics of rice

The different management measures directly influenced the economics as shown in (Table 3) and revealed that cost of cultivation was highest in Weed free (Farmers practices) due to manual weeding required which is high labourand became cost intensive compared to herbicide treatments. Among the herbicide treatments,combine application of Pyrazosulfuron (Sathi 10% WP) @ 200 g ha^{-1}+ Bispyribac Sodium (Nominee gold) @ 200 g ha^{-1}at 20-25 days after sowing recorded highestgrossand net returns due to higher grain yieldfollowed by Pyrazosulfuron 10% WP @ 200g ha^{-1}, Bispyribac sodium @ 200 g ha^{-1}, 2,4-D @ 1.0 kg a.i. ha^{-1} and Pendimethalin @ 1.0 kg a.i. ha^{-1}. Upasani and Barla (2014) reported the similar results which revealed that application of pyrazosulfuron 25 g ha^{-1} recorded maximum net return (Rs. 3216 ha^{-1}). In spite of the B:C ratio recorded was same in the two treatments (2.8) *viz.*,combine application of Pyrazosulfuron @ 200 g ha^{-1}+ Bispyribac Sodium @ 200 g ha^{-1}and Pyrazosulfuron 10% WP @ 200g ha^{-1} due to the low cost and highergrain and straw yield than other herbicidal treatments. Weedfree situation observed lesser B: C ratio than other treatments due to more manual weeding high labour with resulting enhance the cost of cultivation. Similar result were also reported by Yaduraju and Mishra (2008). The lowest B: C ratio ware observed with the treatments of the weedy check.

Based on the experiment result, it may be finalized that among all the herbicidal treatments, Pyrazosulfuron @ 200 g ha^{-1}+ Bispyribac sodium @ 200 g ha^{-1}@ 20-25 days after sowing (DAS)is most effective weed control measure with weed control efficiency as (95.9%) and for getting higher grain yield (62.2 q ha^{-1}). Rice weeds treated with other herbicides *viz.*,Pyrazosulfuron 10% WP @ 200g ha^{-1},Bispyribac sodium @ 200 g ha^{-1} and 2,4-D @ 1.0 kg a.i. ha^{-1} were also found effective for controlling of weed. Therefore,this herbicide should be opted to better control of all weeds *viz.*,grasses, sedges and broad leaf weeds underdirect seeded upland/ aerobic rice.

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