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Effect of integrated weed management practices on weed dynamics of dry direct seeded rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted during the *kharif* season of 2017 at the research farm of RPCAU, Pusa, Samastipur, Bihar to study the, Integrated weed management practices on weed dynamics and grain yield of Dry Direct Seeded Rice. The experiment was conducted in Randomized Block Design having 10 treatments with 3 replications. Among all the weed management practices both hand weeding and herbicidal treatments had reflective effect on weed population and weed dry matter accumulation as well as reflected in their superiority over the weedy check. Hand weedings at 20, 40 and 60 DAS was found significantly superior over all the integrated weed management practices on weed growth of dry direct seeded rice. Amongst herbicidal treatments Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* two hand weedings at 20 and 40 DAS was superior on to rest of all herbicidal treatments for dry direct seeded rice during the year of experimentation.

Keywords: Integrated weed management practices, weed dynamics, dry direct seeded rice, (*Oryza sativa* L.)

Introduction
Rice (*Oryza sativa* L.) is the leading cereal of the world (Ashraf *et al*., 2006), and more than half of the human race depend on rice for their daily sustenance (Chauhan and Johnson, 2011).Almost 90% area and production of the world's rice produced and consumed in Asia. The world's total area under rice cultivation is 161.1 million ha and production is about 487.5 million tons along with the productivity of 3.03 ton/ha (STASTISTA –The Statics Portal 2017-18**).** In India, Rice is cultivated in 44.1 million hectare area with an annual production of 110.2 million tons and productivity is 2.5 ton/ha (India Stat – Advance Estimate, 2017- 18). In Bihar, Rice is cultivated on 3.2 million ha area with the production of 6.8 million tons and the productivity is 2.1 ton/ha (Directorate of economics statistics, Govt. of Bihar, 2017-18).Rice is grown in both *kharif* and *Rabi* seasons under diverse ecological and climatic conditions apart from socio-economic diversities of the state. 33% of total rice land has got irrigation facilities and rest is totally dependent upon rainfall. Dry seeding consists of sowing dry seeds on dry (unsaturated) soils. Seeds can be broadcasted, drilled or dibbled.

Weeds are the universal pest in rice and causes yield loss of 72.6% in Direct seeded rice (Kolhe and Tripathi, 1998) [7]. Damage caused by weeds cannot be identified in early stage as compared to insect damage; so that weeds act as hidden war on crop plants. Early emergence of weeds along with crop seedlings and their rapid growth result in a severe crop weed competition for light, nutrients, moisture and space in direct seeded rice. Weeds will adversely affect the yield, quality and cost of production due to competition for various growth factors (Singh, 2008). Because of wide adaptability and faster growth, weeds dominate the crops habitat and reduce the yield potential (Rao. 2011). On an average yield loss due to weed competition ranges from 15-20%, but in severe cases it may exceed 50% (Hasanuzzaman *et al*., 2009) or even complete crop failure (Jayadeva *et al*., 2011) [6].

Materials and methods
An integrated weed management trial was conducted at University Research Farm, Pusa, Samastipur during *kharif* 2017 to find out the effective herbicides for weed management in dry direct seeded rice. The experiment was laid out in Randomized block design with ten treatments and three replications. T_1: Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* Bispyribac-Na @ 25 g/ha at 20 DAS, T_2: Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* two hand weeding's at 20 & 40 DAS, T_3: Stale seedbed using Glyphosate @ 1 kg/ha at 10 DBS *fb* Bispyribac-Na @ 25 g/ha at 20 DAS, T_4: 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, 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, T_6 : Stale seedbed using Glyphosate @ 1 kg/ha at 10 DBS *fb* Mulch @ 5 t/ha (By wheat straw) *fb* Bispyribac-Na @ 25 g/ha at 20 DAS, T_7 :Pendimethalin @ 1 kg/ha at 0-2 DAS & *Sesbania* co-culture *fb* 2,4-D Na 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 Na salt @ 0.5 kg/ha at 20 DAS *fb* one hand weeding at 40 DAS, T_9 : Weed free (By hand weeding's at 20, 40 & 60 DAS) and T_{10} : Weedy check.

The fertilizer dose *viz*. 120-60-40 kg/ha N-P_2O_5-K_2O were applied in experimental field. Nitrogen was applied through urea and DAP and Phosphorus through DAP whereas Potassium was applied through MOP. $^1/_3{}^{rd}$ dose of nitrogen and full dose of phosphorus and potassium were applied as basal dose at the time of sowing and remaining $^2/_3{}^{rd}$ dose of nitrogen was applied in two equal splits at 30 and 60 DAS. Crop seeds were treated with SAAF (Carbendazim+Mancozeb) @ 3 g/kgseed before sowing to protect the crops from seed borne diseases. Seed of *sesbania* was sowing in between rows just after seeding of rice for brown manuring and was knock down at 20 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 with the help of Pendimethalin 0-2 DAS and post-emergence herbicides with the help of Bispyribac-Na and 2, 4-D at 20 DAS. Manual weeding's are applied at 20, 40 and 60 DAS.

Weed population was counted from an area enclosed in a quadrant of 0.50 m^2 from each plot and then converted into per meter square. Weeds were removed from an area of 0.50 m^2 and were cleaned, washed, air dried and then kept in the oven at 60^0C till constant weight reached. The dry weight of weeds was expressed on oven dry basis in g/m^2.Weed control efficiency (WCE) was computed by the formula:

$$\text{WCE (\%)} = \frac{X-Y}{X} \times 100$$

Where,

X = Dry weight of weed in un weeded check, and
Y = Dry weight of weed under the treatment for which WCE is being calculated.

The efficacy of the weed index was calculated by the following formula:

$$\text{W.I. (\%)} = \frac{X-Y}{X} \times 100$$

Where, X was the grain yield (q/ha) in weed free plot, Y was the grain yield (q/ha) in treated plot.

Result and discussion

It is very much needed to know the type of weeds associated with dry direct seeded rice before taking a suitable integrated weed management practices. In the present study, different weed species posed serious problem in the dry direct seeded rice. This incidence of weeds might be due to their inherent ability of germination, early maturity, early seeding vigor, rooting habit and speedy growth under the favorable climatic condition.

Weed population

The dominance of three types of weeds *viz*. sedges, broad leaved weeds and grasses, commonly weed population/m^2 were considered at different stages of rice crop. The weed population revealed a decreasing trend from 30 DAS to 90 DAS in all the weed management practices except weedy check. Weed free (by hand weeding thrice at 20, 40 and 60 DAS) treated plots exhibited significantly lowest weed population of 9.05, 7.85 and 6.56 /m^2 at 30, 60 and 90 DAS, respectively. This might be due to timely suppression of weeds by intercultural tools. The weeds were uprooted and killed. Similar findings were observed by Pandey *et al*, 1997 and Satyanarayan *et al.*, 1997 [14].

Among different herbicidal treatments, application of Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* two hand weeding's at 20 & 40 DAS (T_2) recorded significantly the lowest weed population of 11.34, 8.05 and 7.74/m^2 at 30, 60 and 90 DAS, respectively followed by 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 (T_8),Mulch @ 5 t/ha (By wheat straw) *fb* Bispyribac Na @ 25 g/ha at 20 DAS *fb* one hand weeding at 40 DAS (T_5) 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 (T_4). The lower weed density with these treatments might be due to inherent capability of the chemical to affect the cell division, cell growth and hindering the germination of weeds. The finding was in conformity with the finding of Bhagirath *et al*., 2011 [2].

Weed Dry Matter (g/m^2)

There was a decreasing trend in the dry weight of weeds with the increase of crop age up to 90 DAS. Weed free *i.e* by hand weeding thrice recorded lowest weed biomass of 17.95, 16.79 and 15.22 g/m^2 at 30, 60 and 90 DAS respectively *i.e* at all growth stages of crop, and weedy check revealed significantly highest weed dry matter/m^2. It might be due to removal of most weed flora at the time of intercultural operation, thus, reduced in weed biomass. Similar findings were also given by Pandey *et al*., 1997 and Satyanarayan *et al*., 1997 [14].

Among different herbicidal treatment application of Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* two hand weeding's at 20 and 40 DAS, recorded significantly lowest weed dry matter *i.e*. (26.55, 17.75 and 17.25 g/m^2) at 30, 60 and 90 DAS, respectively which was closely followed by T_8 - 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 (28.87, 18.32 and 16.89 g/m^2), 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 (27.54, 19.78 and 18.05 g/m^2) and T_4 - 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 (31.45, 20.95 and 18.99 g/m^2). The lowest weed biomass observed with these treatments was due to effective control of leading weed species from the establishment as well as advancement of crop growth stage. This finding is in conformity with the findings of Ramachandiran *et al*., 2012 [10].

Weed Control Efficiency and Weed Index (%)

Weed control efficiency recorded at 60 DAS because this stage had recorded maximum weed population and weed dry weight (g/m^2). Among all the integrated weed management practices, treatment T_9 - Weed free (By hand weeding's at 20, 40 and 60 DAS) recorded highest Weed Control Efficiency

(WCE) of 77.54%, which might be due to decrease in weed biomass as compared to rest of the weed management practices. The highest WCE with weed free treatment *i.e* thrice hand weeding also reported by Singh *et al.*, 2014 [16] and Walia *et al.*, 2012 [18].

Among the different herbicidal treatments, the highest WCE was obtained with treatment T_2-Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* two hand weeding's at 20 & 40 DAS (76.26%),*fb*T_8-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 (75.50%) and 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 (73.54%). The highest WCE with Pendimethalin *fb* manual weeding also reported by Mahajan *et al.*, 2009 [8].

However, weed index followed just opposite trend of Weed Control Efficiency. The reason attributed is the better growth of crop with more yield attributes and yield at higher doses, hence less loss due to weeds despite of their luxuriant growth. Lower weed index represents here the less yield losses due to weed in these treatments. Whereas, Pendimethalin is more or less an omni effective herbicide against weed flora. However, the combination of Pendimethalin with manual weeding again a specific rice herbicide may be capable of suppressing wider range of weeds which are always expected there in direct seeded rice crop sown either in dry condition or in wet condition. This explains the greater efficacy of Pendimethalin at pre-emergence and thereafter hand weeding at critical crop growth stages. These results are in conformity with Saha *et al*. (2005) [13] and Ramesh *et al*. (2009) [11].

Table: Effect of different weed management practices on Weed Population/m^2, Weed dry matter (g/m^2) WCE (%) and WI (%) of dry direct seeded rice.

Treatments	Weed Population/m^2			Weed Dry Matter (g/m^2)			WCE (%)	WI (%)
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS		
T_1	16.95	13.56	12.77	38.59	30.44	29.35	59.29	16.08
T_2	11.34	8.05	7.74	26.55	17.75	17.25	76.26	3.71
T_3	17.25	15.77	14.10	35.95	32.89	30.59	56.01	17.83
T_4	14.56	9.74	8.26	31.45	20.95	18.99	71.98	12.29
T_5	13.65	9.01	8.80	27.54	19.78	18.05	73.54	10.05
T_6	16.22	12.56	11.39	33.75	29.22	25.65	60.92	15.10
T_7	14.95	11.59	11.09	30.69	23.66	24.78	68.36	14.02
T_8	12.87	8.42	7.84	28.87	18.32	16.89	75.50	9.35
T_9	9.05	7.85	6.56	17.95	16.79	15.22	77.54	-
T_{10}	32.56	34.75	35.54	68.62	74.78	76.68	-	45.21
SEm±	0.91	0.80	0.78	1.64	1.16	0.98	1.35	2.26
CD (P=0.05)	2.71	2.37	2.32	4.92	3.48	2.95	4.05	6.78

Conclusion

The lowest weed count, weed dry weight and highest weed control efficiency were recorded by treatment T_9-Weed free (By hand weedings at 20, 40 and 60 DAS). Among herbicidal treatments the lowest weed count, weed dry weight and highest weed control efficiency were recorded by treatment T_2-Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* two hand weedings at 20 & 40 DAS, which was significantly superior among all the treatments and statistically at par with treatment T_2-Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* two hand weedings 20 & 40 DAS and T_8 - 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.The highest grain yield of rice were recorded by treatment T_9 - Weed free (By hand weedings at 20, 40 and 60 DAS). Among herbicidal treatments the highest grain yield were recorded by treatment T_2-Pendimethalin @ 1 kg/ha at 0-2 DAS *fb* two hand weedings at 20 & 40 DAS.

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