Oryza Vol. 54 No. 1, 2017 (29-36)

Effect of weed management practices on yield and yield attributes of wet direct seeded rice under lowland ecosystem of Assam

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Received : 02 February 2017 Accepted : 08 May 2017 Published : 19 May 2017

ABSTRACT

Field experiment was conducted at Agricultural Farm of the Regional Rainfed Lowland Rice Research Institute, Gerua, Assam during early ahu (summer) season of 2015 and 2016 to study the influence of different weed management practices on yield and yield attributes of wet direct seeded rice sown through drum seeder. The dominant weed flora in the experimental field consisted of sedges Cyperus difformis L., *Scirpus incurvatus* Roxb., *grasses Leptochloa chinensis* L., *Echinochloa glabrescens, Echinochloa colona* L. *and broad-leaved weed Ludwigia adscendes* L. *The composition of grasses, sedges and broad-leaved weeds in weedy check plot at 60 DAS was 15.1, 71.5 and 13.4%, respectively. There was 37.3% reduction in the grain yield of rice due to competition with weeds in the weedy plots. All the weed control treatments significantly reduced weed population, dry matter and increased grain yield of rice compared to weedy check. Hand weeding twice recorded grain yield of 5.64 t ha^{-1} resulting in 54.5% increase over weedy check. Mechanical weeding followed by one hand weeding recorded reduction in grain yield of 9.2% over hand weeding twice. Application of flucetosulfuron at 25 g ha^{-1} (5.42 t ha^{-1}), bispyribac sodium at 30 g ha^{-1} (5.40 t ha^{-1}), azimsulfuron at 35 g ha^{-1}(5.38 t ha^{-1}) and bensulfuron methyl+pretilachlor at 60+600 g ha^{-1} recorded grain yield on par with the hand weeding twice. Tank mix application of azimsulfuron+bispyribac sodium recorded 2.2% and 1.9% only, increase in grain yield over its single application.*

Key words: *Drum seeder, rice yield, wet direct seeded rice, weed management practices*

Rice (*Oryza sativa* L.) is the foremost staple food in Asia, where about 92% of the global rice is produced and consumed (IRRI 2012). It is the main staple food in the Asia and the Pacific region, providing almost 39% of calories (Yaduraju and Rao 2013). The term 'rice is life' is most appropriate for India as this crop plays vital role in country's food security and is the backbone of livelihood for millions of rural house hold (Pathak *et al*. 2011). Rice is the major food crop of North East India and occupies an area of 3.5 m ha, which accounts for 7% of the area and 6.5% of the country's rice production (Kumar *et al.* 2016). In context to Assam, rice is consumed by about 90% of the state population and is grown over an area of 2.64 mha occupying around 74.25% of the cropped area (Pegu and Hazarika 2016). Though rice occupies the dominant portion of the cropped area but the productivity is low due to flood prone fragile ecosystem. One of the important issue responsible for widespread yield stagnation and productivity declines in the rice cropping system is soil quality (Shahid *et al*. 2013). There is a urgent need to focusthe attention on lowland rice ecosystem for increased productivity, profitability,employment-generation potential and soil sustainability which could be ensured by adopting modern scientific agricultural practices (Roy *et al*. 2011; Kumar *et al*. 2016).

Rice is commonly grown by transplanting seedlings into puddled soil (wet tillage) in Assam. This production system is labour, water, and energy-intensive and is becoming less profitable as these resources are becoming increasingly scarce (Kumar and Ladha 2011). These factors demand a major shift from transplanting to direct seeding of rice in irrigated ecosystem. About 89% of total flood prone lowlands in India are distributed in five states of eastern India *viz.*, Asaam, West Bengal, Bihar, Odisha and Eastern Uttar Pradesh. Rice farming is risky in those areas during *Kharif* season due to unpredictable hydrology. Cultivation of rice during dry season offers a great potential for boosting and stabilizing the yield from this fragile ecosystem. In Assam, farmers are shifting to summer rice cultivation (*boro* and *early ahu*) by utilizing the harvested rain water stored in small ditches, village ponds and by tapping the ground water using shallow tube wells. Sowing pre-germinated seeds in wet (saturated) puddle soils offer a good alternative method of crop establishment under such situation (Saha *et al*. 2012; Satapathy *et al*. 2016).

Weeds are recognized as major biological constraints that hinder the attainment of optimal rice productivity (Rao and Nagamani 2010; Prasad *et al*. 2013; Hossain *et al*. 2016). Uncontrolled weed growth in transplanted rice causes 45-51% loss in yield (Veeraputhiran and Balasubramanian 2013), whereas weed growth under direct-seeded rice causes yield loss up to 80% (Jabran *et al*. 2012). The failure and success of the drum seeded rice depends on weed management practices. Therefore, the present study was carried out to evaluate the efficacy of different weed management practices on performance of wet direct seeded early ahu rice in lowland ecosystem of Lower Brahmaputra valley zone of Assam.

MATERIALS AND METHODS

Field experiment was carried out during early *ahu* (summer) seasons of 2015 and 2016 at the agricultural farm of Regional Rainfed Lowland Rice Research Station, Gerua, Assam which is located at 26° 14' 59" N latitude, 90° 33' 44" E longitude and at an altitude of 49 m above mean sea level and characterized in the long-term by sub-tropical monsoon type climate with annual average rainfall of 1500 mm. The meteorological weekly average maximum and minimum temperature during the crop growing period from last week of January to first week of June varied from 24.7 ^{0}C to 32.9 ^{0}C and 7.4 ^{0}C to 17.6 ^{0}C respectively in the first year (2015) and 24.1 ^{0}C to 33.9 ^{0}C and 8.6 ^{0}C to 14.6 ^{0}C respectively in the second year (2016). Total pre-monsoon rainfall during the crop growing season in 2015 was 852.5 mm whereas it was 725.3 mm in 2016. The soil was sandy clay loam in texture, having acidic pH (5.2), high organic carbon (0.96%), medium available nitrogen (276 kg ha^{-2}), medium available Phosphorus (17.5 kg ha^{-1}) and medium in available Potassium (226.3 kg ha^{-1}).

The experiment was laid out in randomized block design and replicated thrice. The treatments consisted of T_1: Azimsulfuron at 35 g ha^{-1} at 20 DAS, T_2: Flucetosulfuron at 25 g ha^{-1} at 20 DAS, T_3: Bispyribac sodium at 30 g ha^{-1} at 20 DAS, T_4: Bensulfuron- methyl +Pretilachlor at 60 + 600 g ha^{-1} at 10 DAS, T_5: Azimsulfuron+ Bispyribac sodium at 22+25 gha^{-1} at 20 DAS, T_6: Flucetosulfuron at 25 g ha^{-1} at 5 DAS fb Bispyribac sodium at 25 gha^{-1} at 20 DAS, T_7: Manual weeding twice at 20 and 40 DAS (Recommended practice), T_8: Mechanical weeding by paddy weeder at 20 DAS fb Manual weeding at 40 DAS, T_9: Weed free check (weeding at 15, 30, 45 and 60 DAS) and T_{10}: Weedy check (Table 1).

Seeds of the variety '*Naveen*' at 30 kg ha^{-1} were soaked in plain water for 48 hours and after filtration seeds were incubated in gunny bags for 48 hours for sprouting. Pre germinated seeds were sown by using 12 row drum seeder at 20 cm x 10 cm spacing on puddled saturated soil. The field was maintained at saturation for initial 10 days after sowing (DAS) to facilitate better establishment of seedlings and thereafter that a water depth of 3-5 cm was maintained till grain filling stage of the crop. A fertilizer dose of 80-40-40 kg ha^{-1} of N- P_2O_5- K_2O was applied as urea, diammonium phosphate (DAP) and muriate of potash (MOP) in the field. One third of nitrogen, full dose of P_2O_5 and one third of K_2O were applied as basal dose at the time of final land preparation and incorporated well in to the soil. Remaining two third of nitrogen and potash was applied in two equal splits at maximum tillering and panicle initiation stage. Weed management was done as per schedule. The herbicides were sprayed with knapsack sprayer fitted with flat fan nozzle using 350 litter of water per hectare. Furadon 3G at 30 kg ha^{-1} was applied at immediately after sowing to protect the seeds from bird damage and to provide insurance

Table 1. Treatments employed in the experiment

Treatments	Trade name of the herbicide	Technical name of the weedicide	Dose (ha^{-1})	Time of application (DAS)
Azimsulfuron @ 35 g ha^{-1} at 20 DAS	Segment	Azimsulfuron- 50% DF	35 g.	20
Flucetosulfuronat @ 25 g ha^{-1} at 20 DAS	ICH- 110	Flucetosulfuron- 10% WP	25 g	20
Bispyribac sodium @ 30 g ha^{-1} at 20 DAS	Nominee gold	Bispyribac Sodium- 10% SC	30 g	20
Bensulfuron-methyl +Pretilachlorat @ 60+ 600 g ha^{-1} at 10 DAS	Londax Power	Bensulfuron Methyl 0.6% + Pretilachlor 6% GR	60+600 g	10
Azimsulfuron+Bispyribac sodium @ 22+25 g ha^{-1} at 20 DAS	Segment + Nominee gold	Azimsulfuron- 50% DF + Bispyribac Sodium- 10% SC	22 + 25 g	20
Flucetosulfuron@ 25 g ha^{-1} at 5 DAS fbBispyribac sodium @ 25 gha^{-1} at 20 DAS	ICH-110 fb. Nominee gold	Flucetosulfuron 10% WP fb. Bispyribac Sodium- 10% SC		5 and 20
Manual weeding twice at 20 and 40 DAS	-	-	-	20 and 40
Paddy weeder at 20 DAS fb Manual weeding at 40 DAS	- -	-	-	20 and 40
Weed free (weeding at 15, 30, 45 and 60 DAS)	-		-	15,30,45 and 60
Weedy check	-	-	-	-

against insect pest. Chloropyriphos at 0.05 % was sprayed at PI stage to protect the crop from stem borer and leaf folder attack. The crop was harvested at maturity.

A quadrate measuring 0.5 m x 0.5 m was randomly placed at four sites in each experimental plot to record weed density at 45 and 60 DAS. Weeds were counted and collected for recording dry weight by drying in oven at 70 ^{0}C until constant weight. The data of weed density and dry matter was converted to m^{-2}. The data on count and dry matter of weeds were subjected to square root transformation [(x+ 0.5)] for statistical analysis.

Weed control efficiency was computed using weed dry weight. To determine WCE of individual treatment, the following formula was used and expressed in percentage.

$$WCE = \frac{WDc - WDt}{WDc} x100$$

Where, WCE = Weed control efficiency

WDC = Weed dry weight in weedy check

WD t = Weed dry weight in treated plot

Weed index was determined by using the following formula (Gill and Vijayakumar 1966) and expressed in percentage.

$$\text{Weed index} = \frac{Ywfc - Yt}{Ywfc} x100$$

Where,

Yw fc = Yield of the crop in weed free check

Y t = Yield of the crop in plot under treatment.

Plant height of selected randomly tillers from each of the experimental unit was recorded from soil level to the tip of flag leaf with the help of a meter scale. Days to 50% flowering and maturity were recorded plot wise. At physiological maturity plant samples from each plot were harvested manually and separated into straw and panicles. The dry weight of straw was determined after oven drying at 70^{0}C to constant weight. Panicles were hand-threshed and the filled spikelets were separated from unfilled spikelets with a blower. All unfilled spikelets were counted to determine the number of unfilled spikelets. Grain yield was determined from each plot and adjusted to the standard moisture content of 0.14 g H_2O g^{-1} fresh weight (Kumar *et al*. 2016, 2017).

The data on observed parameters were subjected to analysis of variance (ANOVA) for randomized block design. The results were presented at 5% level of significance (P> 0.05) and critical difference (CD) values were calculated to compare the treatments.

RESULTS AND DISCUSSIONS

The weed flora of the experimental site was similar during both the years and comprised of sedges *Cyperus difformis* L., *Scirpus incurvatus* Roxb, *Cyperus iria* L., *Fimbristylis miliacea* (L.)Vahl; grasses *Leptochloa chinensis* (L.) Nees, *Echinochloa glabrescens* Munro ex Hook. f., *Echinochloa crusgalli* (L.), P. Beauv., *Echinochloa colona* (L.) Link; broad-leaved weeds (BLW) *Ludwigia adscendes* (L.) Hara, *Ludwigia octovalvis* (Jacq.) P. H. Raven, *Monochoria vaginalis* (Burm.f.) C. Presl ex Kunth, *Marsilea quadrifolia* L.; aquatic weeds *Chara zeylanica* var. diaphana (F. Meyen) R.D. Wood and *Hydrilla verticillata* (L.f.) Royle (Table 2). The composition of grasses, sedges and broad-leaved weeds in weedy check plot at 60 DAS was 15.1, 71.5 and 13.4%, respectively. Similarly Rasid *et al*. (2012) and Naseerudin and Subramanyam 2013 reported the dominance of sedges in W-DSR. *Cyperus difformis*, *Echinochloa glabrescens* and *Ludwigia adscendes* were the dominant weeds among sedges, grasses and BLW respectively.

All the weed control treatments significantly reduced density and dry matter of weeds as compared to that in weedy check. The highest dry matter of weeds in weedy plot might be due to increased population and continuous growth as no weed management practice was applied in weedy check (Table 3). Among the weed control practices hand weeding twice recorded lowest weed dry matter (2.41 g m^{-2}) at 45 DAS, however, at 60 DAS tank-mix application of azimsulfuron + bispyribac sodium recorded lowest weed dry matter (2.8 g m^{-2}). Efficacy of tank mix application of bispyribac sodium + azimsulfuron in terms of lowering weed dry biomass, broad spectrum weed control and increase in grain yield of direct seeded rice reported by Ghosh *et al*. (2017). However, in this study tank -mix application of azimsulfuron + bispyribac sodium does not show any significant effect in terms of weed control efficiency and increase in grain yield over single application of azimsulfuron or bispyribac sodium alone. This might be due to dominance of sedge weeds (71.5%) in the experimental plots. Efficacy of single slot application of azimsulfuron or bispyribac sodium in controlling broad leaved weeds and sedges in rice field is reported by Singh *et al*. (2010); Naseerruddin and Subramanyam, 2013 and Duary *et al*. (2015). Similarly effectiveness of bispyribac sodium in terms of weed control efficiency and increase in rice grain yield in W-DSR also reported by Yadav *et al*. (2011). Application of bensulfuron methyl + pretilachlor recorded significantly reduction in weed population and dry matter which resulted increase in grain yield of rice. Similar findings are also reported by Saha and Rao 2010 and Singh *et al*. (2014). Early post emergence application of flucetosulfuron at 25 g ha^{-1} recorded significantly reduction in weed population and dry matter which resulted increase in grain yield of W-DSR. Bhimal and Pandey (2014) reported the usefulness of flucetosulfuron in terms of reduction in weed dry matter and increase in grain yield

Table 2. Weed flora associated with wet direct seeded rice sown by drum seeder

Scientific name	Common name	Group	Family
Cyperus difformis L.	Small flower Umbrella Sedge	Sedge, Annual herb	Cyperaceae
*Scirpus incurvatus*Roxb.	Bulrush	Sedge, Annual herb	Cyperaceae
Cyperus iria L.	Rice Flat Sedge	Sedge, Annual herb, Occasionally perennial	Cyperaceae
Fimbristylis miliacea (L.) Vahl	Forked Fringe rush	Sedge, Annual/Perennial herb	Cyperaceae
Leptochloa chinensis (L.) Nees	Chinese Sprangle top	Grass, Annual herb	Poaceae
Echinochloa glabrescens Munro ex Hook. f.	Cockspur Grass	Grass, Annual herb	Poaceae
Echinochloa crusgalli (L.) P. Beauv.	Barn yard Grass	Grass, Annual herb	Poaceae
Echinochloa colona (L.) Link	Jungle Rice	Grass, Annual herb	Poaceae
Ludwigia adscendes (L.) Hara	Water Primose	Broad leaf, Perennial herb	Onagraceae
Ludwigia octovalvis (Jacq.) P. H. Raven	False Primose	Broad leaf, Perennial herb	Onagraceae
Monochoria vaginalis (Burm.f.) C. Presl ex Kunth	Oval-leafed	Broad leaf, Annual/ Perennial	Pontederiaceae
Marsilea quadrifolia L.	Four leaf clover	Broad leaf, Perennial	Marsileaceae
Chara zeylanica var. diaphana (F. Meyen) R.D. Wood	Stonewort	Submerged Aquatic	Characeae

Table 3. Effect of weed management practices on weed population, dry matter and WCE in Wet direct seeded rice sown by drum seeder (mean of two years)

Treatments	Weed Population (m^{-2})		Weed dry weight (gm^{-2})		WCE (%)	
	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS
Azimsulfuron @ 35 g ha^{-1} at 20 DAS	4.5 (19.7)	4.2 (17.0)	2.51 (8.7)	4.6 (20.9)	91.4	90.6
Flucetosulfuronat @ 25 g ha^{-1} at 20 DAS	4.5 (19.4)	5.2 (27.0)	3.32 (11.5)	5.4 (28.7)	89.1	87.1
Bispyribac sodium @ 30 g ha^{-1} at 20 DAS	4.9 (23.5)	4.1 (16.0)	3.29 (11.1)	4.3 (17.9)	88.9	91.0
Bensulfuron-methyl +Pretilachlorat @ 60+ 600 g ha^{-1} at 10 DAS	4.6 (20.5)	3.9 (14.4)	3.06 (9.3)	4.0 (15.7)	90.9	93.7
Azimsulfuron+Bispyribac sodium @ 22+25 g ha^{-1} at 20 DAS	4.2 (17.4)	3.8 (13.9)	2.93 (8.4)	2.8 (7.4)	91.0	94.6
Flucetosulfuron @ 25 g ha^{-1} at 5 DAS fb Bispyribac sodium @ 25 gha^{-1} at 20 DAS	3.4 (11.3)	3.8 (14.0)	2.69 (7.1)	3.9 (14.9)	93.1	90.8
Manual weeding twice at 20 and 40 DAS	6.4 (40.7)	6.4 (40.9)	2.41 (5.7)	4.0 (15.3)	94.5	93.6
Paddy weeder at 20 DAS fb Manual weeding at 40 DAS	8.4 (69.5)	8.7 (74.9)	4.31 (19.3)	5.4 (28.2)	78.6	86.6
Weed free (weeding at 15, 30, 45 and 60 DAS	0.7 (0.0)	0.7 (0.0)	0.70 (0.0)	0.70 (0.0)	100.0	100.0
Weedy check	20.7 (426.0)	21.7 (469.3)	10.29 (118.1)	14.36 (219.0)	-	-
CD (p=0.05)	2.3	2.58	1.44	1.35	-	-

*DAS=Days after sowing

Table 4. Effect of weed management practices on growth of wet direct seeded rice sown by drum seeder (mean of two years)

Treatments	Plant height (cm)	Tillers (m^{-2})	Panicle length (cm)	Days to 50% flowering	Spikelet fertility (%)
Azimsulfuron @ 35 g ha^{-1} at 20 DAS	107.0	608.5	23.2	90.3	77.5
Flucetosulfuronat @ 25 g ha^{-1} at 20 DAS	109.4	633.2	23.1	91.4	79.7
Bispyribac sodium @ 30 g ha^{-1} at 20 DAS	106.5	637.4	23.3	91.4	77.1
Bensulfuron-methyl +Pretilachlorat @ 60+ 600 g ha^{-1} at 10 DAS	109.0	639.3	23.8	91.7	78.3
Azimsulfuron+Bispyribac sodium @ 22+25 g ha^{-1} at 20 DAS	108.2	622.4	23.7	90.8	78.9
Flucetosulfuron @ 25 g ha^{-1} at 5 DAS fb Bispyribac sodium @ 25 gha^{-1} at 20 DAS	106.8	615.0	23.4	92.7	77.9
Manual weeding twice at 20 and 40 DAS	108.3	626.3	23.3	91.7	79.6
Paddy weeder at 20 DAS fb Manual weeding at 40 DAS	108.0	618.0	23.0	91.5	76.4
Weed free (weeding at 15, 30, 45 and 60 DAS	108.0	646.4	24.2	91.7	80.6
Weedy check	97.5	533.3	21.6	92.0	74.9
CD (p=0.05)	4.83	61.19	1.0	NS	NS

*DAS=Days after sowing

of transplanted rice.

All weed control treatments recorded significantly higher plant height, number of tillers m^{-2} than weedy check. Various weed management practices does not recorded any significant difference in days to 50% flowering and spikelet fertility % against weedy plot. We observed low filled spikelet percentage which might be due to occurrence of continuous rain during flowering period, but it does not affect the grain yield because of higher number of effective tillers per unit area.

Hand weeding twice recorded grain yield of 5.64 t ha^{-1} resulting in 54.5% increase over weedy check. Mechanical weeding followed by one hand weeding recorded reduction in grain of 9.2% over hand weeding twice. The yield reduction might be due to poor control of weeds at early crop growth stage by paddy weeder. Single shot herbicides like

Table 5. Effect of weed management practices on yield and yield components of wet direct seeded rice sown by drum seeder (mean of two years)

Treatments	Panicles (m^{-2})	Grains panicle $^{-1}$	Test weight(g)	Grain yield(t ha^{-1})	WI (%)
Azimsulfuron @ 35 g ha^{-1} at 20 DAS	374.0	89.2	21.7	5.38	7.6
Flucetosulfuronat @ 25 g ha^{-1} at 20 DAS	383.5	88.0	21.4	5.42	7.0
Bispyribac sodium @ 30 g ha^{-1} at 20 DAS	361.0	88.0	21.6	5.40	7.3
Bensulfuron-methyl +Pretilachlorat @ 60+ 600 g ha^{-1} at 10 DAS	378.5	89.4	21.8	5.39	6.9
Azimsulfuron+Bispyribac sodium @ 22+25 g ha^{-1} at 20 DAS	387.9	91.9	21.6	5.50	5.5
Flucetosulfuron @ 25 g ha^{-1} at 5 DAS fbBispyribac sodium @ 25 gha^{-1} at 20 DAS	366.5	88.1	21.1	5.35	8.1
Manual weeding twice at 20 and 40 DAS	389.0	95.3	21.1	5.64	3.2
Paddy weeder at 20 DAS fb Manual weeding at 40 DAS	353.5	85.4	21.6	5.12	12.2
Weed free (weeding at 15, 30, 45 and 60 DAS	398.7	99.3	21.5	5.82	-
Weedy check	283.9	71.8	21.0	3.65	37.3
CD (p=0.05)	37.15	9.76	NS	0.35	-

DAS=Days after sowing

flucetosulfuron at 25 g ha^{-1} (5.42 t ha^{-1}), bispyribac sodium at 30 g ha^{-1} (5.40 t ha^{-1}) and azimsulfuron at 35 g ha^{-1}(5.38 t ha^{-1}) recorded 48.5%, 47.9% and 47.4% increase in grain yield over weedy check. However, the herbicide combination (tank -mix) azimsulfuron+ bispyribac sodium recorded 2.2% and 1.9% only, increase in grain yield over its single application. No significant yield advantage of the tank mix application over its single application may be due to dominance of sedge weeds in the field. The ready mix application of bensulfuron methyl+pretilachlor recorded 47.7% increase in grain yield over control. Sequential application of flucetosulfuron at 5DAS followed by post emergence application of bispyribac sodium does not recordany significant increase in grain yield over its single application. This may be due to pytotoxicity of fluecetosufuron when applied at 5 DAS. However flucetosulfuron when applied at 20 DAS does not show any pytotoxicity to rice crop (data not presented).

Weed infestation in drum seeded W-DSR recorded grain yield reduction of 37.3% as compared to weed free plots. Manual weeding twice recorded lowest WI (3.2%) followed by application of azimsulfuron + bispyribac sodium at 22+25 g ha^{-1} (5.5%), bensulfuron methyl+pretilachlor (6.9%), flucetosulfuron (7.0%), bispyribac sodium (7.2%) and azimsulfuron (7.6%)(Table 5).

From the present study, it can be concluded that weed infestation cause grain yield reduction of 37.3% in drum seedred rice during early *ahu* season. The laborious, time consuming, costly hand weeding operation in W-DSR can be replaced by the low dose high efficacy early post emergence herbicides like flucetosulfuron 25 g ha^{-1} or azimsulfuron 35 g ha^{-1} or bispyribac sodium 30 g ha^{-1} or bensulfuron methyl+pretilachlor 60+600 g ha^{-1} for broad spectrum weed control and sustainable grain yield.

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