ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Assessing the efficacy of new low dose herbicide molecule in puddled direct seeded rice

B. Sreedevi, R.M. Kumar, Aarti Singh*, M.D. Tuti, Soumya Saha and S.R. Voleti

ICAR-Indian Institute of Rice Research, Hyderabad, Telangana-500030
**Corresponding author: aartisingh810@gmail.com*

Received: 8th Nov. 2018 Accepted: 24rd Dec. 2018

Abstract

A field experiment was conducted to evaluate the effectiveness of new low dose post-emergence herbicide, florpyrauxifen-benzyl for broad-spectrum weed control in puddled direct seeded rice at five AICRIP locations i.e. Navsari, Vadgaon, Aduthurai, Karjat and Nellore. Experiment was laid out in randomized block design to test seven treatments, *viz.* T_1- florpyrauxifen-benzyl at 31.25 g a.i./ha, T_2- florpyrauxifen-benzyl at 37.5 g a.i./ha, T_3- bispyribac sodium at 30 g a.i./ha, T_4- pyrazosulfuron-ethyl at 25 g a.i./ha followed by metsulfuron-methyl + chlorimuron-ethyl at 4 g a.i./ha, T_5- Weed free condition, T_6- hand weeding twice and T_7- weedy check and were replicated thrice. Application of florpyrauxifen-benzyl reduced the density, dry biomass of weeds and increased the weed control efficiency to the tune of 78.3% and remained comparable to hand weeding twice. Florpyrauxifen-benzyl at 37.5 g a.i./ha recorded higher values of yield attributes thus leading to higher yield (4.92 t/ha) and was equally effective as standard check bispyribac sodium 30 g a.i./ha in suppressing the weeds and recording comparable yield (4.80 t/ha). Higher Energy productivity was noted under weed free situation (0.845) and was followed by application of pyrazosulfuron- ethyl 25 g a.i./ha *fb* metsulfuron-methyl + chlorimuron-ethyl at 4 g a.i./ha (0.746). Florpyrauxifen-benzyl at 37.5 g a.i./ha can be used as an alternative herbicide to standard recommended herbicide bispyribac sodium at 30 g a.i./ha under direct sown conditions.

Key words: florpyrauxifen-benzyl, direct seeded rice, yield, weed control efficiency, weed index

Introduction

Rice is consumed by more than half of the world's population and India is the second largest producer of rice in the world and is the major cereal crop of the country. Most of rice is grown by transplanting seedlings into puddled soils and is then kept flooded for most of the growing season. However, transplanting consumes large amount of labor, water and energy which are gradually becoming scarce and thus necessitates the need to shift to direct seeded rice (DSR) systems. But, one of the major constraints to the adoption of direct seeded rice are weeds. Weeds cause heavy damage to direct seeded rice (DSR) crop and yield losses due to weeds in India range from 20-85% (Rao *et al*. 2007) and in severe infestation it can cause crop losses to the tune of 100% (Prasad, 2011; Singh *et al*. 2014). Managing weeds in rice is one of the costliest methods in the rice production program and varies with rice ecosystem, soils and agro-climatic conditions (Sreedevi *et al*. 2012). Among all the methods, chemical control is effective, cheap and reliable option (Krishnamurthy *et al*. 2010). The main reason for the poor efficacy of weed control in direct seeded rice is that the herbicides used have narrow spectrum with a single mode of action which is unable to provide season long weed control (Mahajan and Chauhan, 2013) which leads to the development of herbicide resistance in weeds. Moreover, rice herbicides presently used are mainly pre-emergence and weeds coming at later stages of crop growth are not controlled effectively. Therefore, use of herbicides which provide broad-spectrum post-emergence weed control can prove to be desirable for effective weed management in direct seeded rice systems (IIRR Progress Report, 2016). Florpyrauxifen-benzyl is a novel 6-arylpicolinate molecule constituting of highly substituted 4 amino pyridine ring and a selective post-emergence weed killer with short persistence in soil. Few broad spectrum molecules are available to evaluate and identify new low dose post-emergence herbicides under direct seeded conditions in different agro-climatic locations for effective suppression of weeds. Therefore, present investigation was undertaken under All India Coordinated Rice Improvement Program (AICRIP).

Materials and methods

A field experiment was conducted during *Kharif* 2016 at five different AICRIP locations, *viz*. Navsari, Vadgaon, Aduthurai, Karjat and Nellore with an objective to find out the suitability of new herbicide along with standard recommended herbicides in direct seeded rice. The treatments comprised of T_1- florpyrauxifen-benzyl at 31.25 g a.i./ha, T_2- florpyrauxifen-benzyl at 37.5 g a.i./ha, T_3- bispyribac sodium at 30 g a.i./ha, T_4- pyrazosulfuron at 25 g a.i./ha *fb* by metsulfuron-methyl + chlorimuron-ethyl at 4 g a.i./ha, T_5- Weed free condition, T_6- Hand weeding twice and T_7- Weedy check. The treatments were tested in randomized block design with three replications. The herbicide florpyrauxifen-benzyl was applied at 4-7 leaf stage of weeds after sowing of rice crop, bispyribac sodium at 3-4 leaf stage of weeds and pyrazosulfuron ethyl within 3-5 days after sowing (DAS) and metsulfuron-methyl + chlorimuron-ethyl at 25-30 DAS. The treatment hand weeding twice was taken up at 25 and 45 DAS. High yielding variety of the specific location with recommended package of practices was adopted in the trial at test locations. The soil type varied from sandy loam to nearly black soils. Full dose of P and K and half dose of N was applied at the time of sowing and remaining half dose of N was applied in two equal splits at tillering and panicle initiation stage at all the locations. Weed population and biomass were recorded at flowering stage using iron quadrat of standard size.

Weed control efficiency and weed index were calculated using the formula:

$$\text{WCE (\%)} = \frac{\text{DMC} - \text{DMT}}{\text{DMC}} \times 100$$

Where, DMC is dry-matter of weeds in the control plots and DMT dry matter of weeds in treated plots.

$$\text{Weed Index} = \frac{X - Y}{X} \times 100$$

Where, X= Yield in weed free plot; Y= Yield in treated plot

Energy parameters were calculated as follows:

Input energy: The energy input was calculated as the summation of energy requirements for labour, farm machinery, seed, fertilizers and irrigation used in the system and is expressed in GJ/ha.

Output energy:

Output energy from the main product (grain) and by-product (straw) was calculated by multiplying the amount of production and its corresponding energy equivalent and conversion coefficients.

Energy productivity (EP):

$$\text{Energy productivity (kg/MJ)} = \frac{\text{Grain + straw yield (kg/ha)}}{\text{Total energy input (MJ/ha)}} \times 100$$

Statistical analysis: The data were subjected to analysis of variance using the procedure given by Gomez and Gomez (1976). Weed density data was subjected to square-root transformation [$\sqrt{(x + 0.5)}$] before analysis. The data for all the five locations were pooled.

Results and discussion

Weed flora of the experimental field

The major weed flora observed in the experimental field included grass weeds, sedges and broad leaved weeds. Among the grasses, *Echinochloa colonum*, *Echinochloa crusgalli*, *Eleusine indica*, *Digitaria sanguinalis* were the dominant weed species. Among the sedges, *Cyperus difformis*, *Cyperus iria*, *Cyperus rotundus* and *Fimbristylis miliacea* and among the broad leaved weeds, *Ammanica baccifera*, *Caesulia axillaris*, *Commelina benghalensis* and *Eclipta alba* were found. The composition of grasses, sedges and broad leaf weeds were 51%, 33% and 15% of the total weed population in weedy check. Relative proportion of grasses as noted in weedy check was more compared to sedges and broad leaf weeds. It is in conformity with the findings of Krishnamurthy *et al*. 2010 and Nikhil and Singh 2014, who reported dominance of grasses under direct seeded conditions.

Effect on weed population

The data on weed population at flowering stage indicated that all the weed control treatments significantly suppressed the population of grasses, sedges as well as broad leaf weeds (Table 1). Application of the herbicide florpyrauxifen-benzyl at both the doses was effective in checking the grassy weed population and comparable to the efficacy of other test herbicides in suppressing grassy weeds in direct seeded rice .Sedge population was lowest in weed free condition. And all test herbicides recorded onpar. The broadleaf weed population was lowest in weed free treatment and pyrazosulfuron fb metsulfuron methyl+chlorimuron ethyl application.

Effect on dry weed biomass

The data on total weed biomass indicated that significant reduction in weed biomass was recorded in all the herbicide treatments compared to weedy check (Table 1). Among the herbicide treated plots, florpyrauxifen-benzyl at 37.5 g a..i/ha was effective in recording lower biomass of grasses and sedges. All the weed control treatments recorded significantly lower biomass accumulation than the weedy check. Bispyribac sodium 30 g a.i/ha was equally effective as florpyrauxifen-benzyl at 37.5 g a.i./ha in reducing the grasses and broad leaf weeds.

Table 1: Weed population, weed dry biomass accumulation and weed indices at flowering stage in direct seeded rice in *Kharif* 2016 across pooled data of five locations

Treatments	Weed population(No/ m^2)			Weed dry biomass (g /m^2)			Total weed density (No./m^2)	Total weed biomass (g/m^2)	Weed control efficiency (%)	Weed Index
	Grasses	Sedges	BLWs	Grasses	Sedges	BLWs				
T1-Florpyrauxifen-benzyl (31.25g a.i./ha)	2.86 (10.80)	1.76 (3.34)	1.60 (2.28)	27.47	4.28	4.80	6.22 (16.5)	35.50	70.00	14.10
T2-Florpyrauxifen-benzyl (37.5g a.i./ha)	2.38 (6.87)	1.42 (2.04)	1.64 (2.37)	17.35	2.64	5.39	5.44 (11.28)	25.40	78.30	8.30
T3-Bispyribac sodium 30 g a.i./ha	2.59 (8.17)	2.22 (5.74)	1.71 (2.58)	20.01	8.37	6.53	6.52 (16.5)	35.00	70.10	10.60
T4-Pyrazosulfuron-ethyl 25 g a.i./ha *fb* metsulfuron-methyl + chlorimuron-ethyl 4 g a.i./ha	3.00 (13.51)	1.63 (3.05)	1.49 (1.96)	30.57	3.49	3.98	6.12 (18.52)	38.00	68.00	8.50
T5-Weed free Condition	0.81 (0.20)	0.83 (0.26)	1.03 (0.86)	0.44	0.20	0.29	2.67 (9.32)	1.00	100.00	-
T6-Hand weeding twice at 20 and 45 DAS	1.93 (3.48)	1.77 (3.21)	2.07 (4.45)	6.79	5.04	10.34	5.77 (11.14)	22.20	81.00	0.90
T7-Weedy check	5.10 (31.02)	3.97 (20.06)	3.04 (9.22)	61.56	30.27	25.47	12.11 (60.3)	117.3	-	53.20
LSD(p=0.05)	0.61	0.56	0.51	10.08	3.17	3.00	1.68	16.25	NA	NA

Values given in parenthesis are the original values

NA-Not Statistically Analysed

Weed Indices

The efficiency of various treatments with respect to weed control efficiency fluctuated to a greater extent under the influence of various weed control treatments (Table 1). Among the herbicides, weed control efficiency was highest under the application of florpyrauxifen-benzyl at 37.5 g a.i./ha (78.3%) and was followed bispyribac sodium 30 g a.i./ha and florpyrauxifen-benzyl lower dose. Lower weed index was noted with florpyrauxifen-benzyl at 37.5 g a.i./ha (8.3) and was followed by pyrazosulfuron ethyl at 25 g a.i./ha *fb* metsulfuron-methyl + chlorimuron-ethyl at 4 g a.i./ha (8.5). Weedy check recorded the highest weed index (53.2) which indicated the losses caused due to weeds. In general, weed control efficiency increased and weed index declined with increase in the dose of florpyrauxifen-benzyl. Application of herbicides enhanced weed control efficiency and reduced weed index due to restricted weed growth, subsequently resulting in lower dry matter production by weeds and higher yield. Similar results have been reported by Suria *et al*. 2011.

Yield attributes and yield

Application of herbicides significantly influenced the yield attributes, *viz*. panicles/m^2, panicle weight and 1000 grain weight compared to weedy check (Table 2). The highest number of panicles was recorded in weed free condition. Among the herbicides, highest panicles/m^2 was noted with bispyribac sodium at 30 g a.i./ha and was similar to florpyrauxifen-benzyl at 37.5 g a.i./ha. Panicle weight and 1000 grain weight were not influenced by herbicide treatments.

Significant variation in grain yield was observed due to herbicide applications. The highest grain yield loss due to weeds to the tune of 57% was noted in weedy check. The florpyrauxifen benzyl at 37.5 g ai./ha recorded the highest yield (4.92 t/ha) and was at par to combination herbicide pyrazosulfuron-ethyl at 25 g a.i./ha *fb* metsulfuron-methyl + chlorimuron-ethyl at 4 g a.i./ha (4.91 t/ha) and bispyribac sodium at 30 g ai.i/ha (4.80 t/ha) Non-significant differences among the herbicides were recorded with respect to grain yield. Lesser yield in unweeded check might be due to higher weed competition and lesser availability of nutrients to the crop plants which resulted in lower grain and straw yield in control plots and is in conformity with the findings of Thakur *et al*. 2011.

It was observed from Figure 1 that grain yield was inversely related with weed biomass and increase in dry matter accumulation by weeds caused significant yield reduction. Negative relationship between weed biomass and grain yield has been reported by various researchers (Mahajan and Chauhan, 2013 and Chauhan *et al*. 2011). The unit increase in weed dry biomass caused a yield reduction by 17.29 kg in. Our results confirm the findings of Singh et *al*. (2008) and Mahajan and Chauhan, (2013).

Table 2: Efficacy of different herbicides on yield attributes, yield and Energy dynamics in direct seeded rice in *Kharif* 2016 across pooled data of five locations

Treatments	Panicle no /m^2	Panicle wt(g)	Test wt(g)	Grain yield (t/ha)	Straw yield (t/ha)	Energy Input (MJ/ha)	Energy Output (MJ/ha)	Energy Productivity (kg/MJ)
T1-Florpyrauxifen-benzyl (31.25g a.i./ha)	265	2.39	20.29	4.61	6.35	15,995	14,717	0.69
T2-Florpyrauxifen-benzyl (37.5g a.i./ha)	292	2.38	20.94	4.92	6.63	15,995	15,530	0.72
T3-Bispyribac sodium 30 g a.i./ha	297	2.46	21.06	4.80	6.89	15,995	15,674	0.73
T4-Pyrazosulfuron-ethyl 25 g a.i./ha *fb* metsulfuron-methyl + chlorimuron-ethyl 4 g a.i./ha	276	2.38	20.75	4.91	7.01	15,995	15,988	0.75
T5-Weed free Condition	341	2.70	21.04	5.37	7.90	16,295	17,778	0.82
T6-Hand weeding twice at 20 and 45 DAS	301	2.41	20.68	4.84	7.16	16,145	16,077	0.74
T7-Weedy check	167	1.49	18.74	2.51	3.92	15,920	8,596	0.40
LSD(p=0.05)	31	0.25	1.23	0.43	0.57	NA	NA	NA

Values given in parenthesis are the original values

NA-Not Statistically Analysed

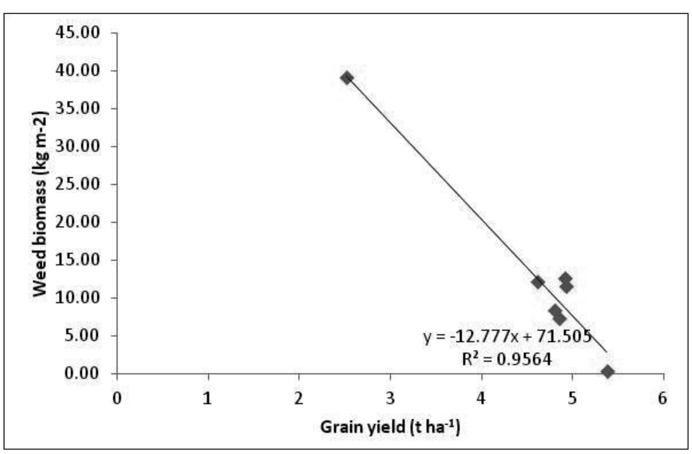

Figure 1: Relationship between grain yield and weed biomass

Energy attributes

The highest input and output energy (MJ/ha) was noted in weed free condition (16,295and 17,778) followed by hand weeding twice (16,145 and 16,077). All the herbicides, recorded same input energy but output energy varied. Among the herbicides, highest output energy (15,988) and productivity (0.746) was noted in application of pyrazosulfuron ethy at 25 g ai./ha *fb* metsulfuron methyl + chlorimuron ethyl at 4 g a.i./ha. Among the herbicide treatments, lowest energy productivity was observed in florpyrauxifen-benzyl at 31.25 g a.i./ha (0.685)

Conclusion

The results of the present study indicate that florpyrauxifen-benzyl at 37.5 g a.i./ha was effective and was similar to other combination herbicides and bispyribac sodium at 30 g a.i./ha based on the results of one season study at five locations, Thus, Post-emergence herbicide, florpyrauxifen-benzyl at 37.5 g a.i./ha at 4-7 leaf stage of weed can be applied in wet seeded puddle rice for efficient weed control to realize more productivity comparable to bispyribac sodium 30 g a.i./ha at 3-4 leaf stage of weeds.

Acknowledgement

The authors are thankful to Dow Agro Sciences Ltd, for providing grant for this study. The authors are also thankful to the Director, ICAR-IIRR and all the co-operators of AICRIP, Rice who co-operated in carrying out the study.

References

Chauhan BS, Singh VP, Kumar A, Johnson DE. 2011. Relations of rice seedling rates to crop and weed growth in aerobic rice. *Field Crops Research*. 121: 105-115.

Gomez K and Gomez A. 1976. Statistical procedures for agricultural research (2nd edition, 1984). John Wiley and Sons Inc., New York, U.S.A.

Indian Institute of Rice Research 2016. Progress Report 2015. Volume-3. Crop Production (Agronomy, Soil Science and Plant Physiology), All India Co-ordinated Rice Improvement Programme (ICAR).

Krishnamurthy P, Sreedevi B, Singh SP and Mahender Kumar R. 2010. Weed Management in Rice. Technical Bulletin. 48, DRR, Rajender Nagar, Hyderabad.

Mahajan G and Chauhan BS. 2013. Herbicide options for weed control in dry-seeded aromatic rice in India. *Weed Technology*. 27: 682–689.

Nikhil KS and Singh UP. 2014. Crop establishment methods and weed management on growth and yield of dry direct-seeded rice. *Indian Journal of Weed Science*. 46 (4): 308-313.

Prasad, R. 2011. Aerobic rice systems. Advances in Agronomy, 111:207-247.

Rao AN, Johnson DE, Sivaprasad B, Ladha JK and Mortimer AM. 2007. Weed management in direct-seeded rice. *Advances in Agronomy*. 93: 153-255.

Singh Y, Singh VP, Chauhan BS, Orr A, Mortimer AM, Johnson DE, Hardy B. 2008. Direct Seeding of Rice and Weed Management in the Irrigated Rice–Wheat Cropping System of the Indo-Gangetic Plains., pp. 180–181.

Singh M, Bhullar MS and Chauhan BS. 2014. The critical period for weed control in dry seeded rice. *Crop Protection*. 66: 80-85.

Suria ASMJ, Juraimi AS, Rahman MM, Man AB and Selamat A. 2011. Efficacy and economics of different herbicides in aerobic rice system. *African Journal of Biotechnology* 10: 8007-8022.

Sreedevi B, Krishnamurthy P, mahender Kumar R and Viraktamath BC. 2012. A ready rekoner of rice weeds. Technical Bulletin No. 64. Directorate of Rice Research, Rajender ngar, Hyderabad-500030, A.P. India.

Thakur R, Shushama M, Upasani RR, Pal SK and Singh MK. 2011. Impact of integrated weed management on dry matter partitioning and productivity of direct seeded rice. *SAARC Journal of Agriculture*. 9 (1): 37-43.