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Grassy weed management in aerobic rice in Indo-Gangetic plains

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ABSTRACT

A replicated field experiment was conducted during 2014 and 2015 to determine the efficacy of herbicides under aerobic soil conditions for selecting suitable herbicide dose towards successful grassy weed management in rice at Krishi Vigyan Kendra Farm, Ashokenagar, West Bengal, India. The results clearly indicated the positive response of herbicide on grassy weeds. Among the herbicide treatments, metamifop 10 EC 125 g/ha resulted in lower number of weed population, (15.67 and 10.90) and higher weed control efficiency 91.55% and 92.60%), during 2014 and 2015, respectively. On an average 64.5% grain yield was recorded over the control. Application of metamifop at 2-3 leaf stage could be the possible alternative options for effective and economic weed control in rice under aerobic system to avoid development of herbicide resistance in weed.

Key words: Aerobic rice, Grasses, Herbicides, Weed control efficacy, Yield

Aerobic rice systems, wherein the crop is established through direct-seeding in non-puddled, non-flooded fields, are among the most promising approaches for saving water (Bhushan *et al.* 2007). Weeds pose a serious threat to the direct-seeded aerobic rice by competing for nutrients, light, space and moisture throughout the growing season (Hussain *et al.* 2008). In aerobic direct-seeded rice, loss of grain yield due to weed competition ranged from 38 to 92% (Singh *et al.* 2008). Therefore, developing a sustainable weed management approach has been a challenge for widespread adoption of aerobic rice technology. Hand weeding is very easy and environment-friendly but tedious and highly labour intensive (Adhikary *et al.* 2014). Farmers very often fail to remove weeds due to unavailability of labor at peak periods (Adhikary and Ghosh 2014). Moreover, morphological similarity between grassy weeds and rice seedlings makes hand weeding difficult at early stages of growth. The weed flora composition and their abundance in aerobic rice differ from that of puddled flooded rice system (Mahajan *et al.* 2009). Information regarding weed flora composition and their response to different herbicides in aerobic rice system is meager. In general, most of the soil applied rice herbicides require moist or even flooded condition for their efficient actions against weeds which is not satisfied under aerobic system. Therefore, the efficacy of herbicides under aerobic soil conditions needs to be evaluated for selecting suitable herbicides towards successful grassy weed management in this system.

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MATERIALS AND METHODS

The experiment was conducted during two consecutive *Kharif* seasons of 2014 and 2015 at the Krishi Vigyan Kendra Farm, Ashokenagar (latitude: 22° 50' 9.6324'' N, longitude: 88° 38' 13.8192'' E and altitude: 10.47m) West Bengal, India. This soil was medium in organic carbon content (0.67%) and the available nutrient status was low in nitrogen, medium range of phosphorus and the potassium status was high with neutral to alkaline in soil reaction. The variety used in this experiment was '*IET-4786*'. The experiment was laid out in randomized block design with seven treatments, *viz.* metamifop 10 EC 75 g/ha, metamifop 100 g/ha, metamifop 125 g/ha, cyhalofop-butyl 10 EC 80 g/ha, cyhalofop-butyl 100 g/ha, two hand weeding at 20 and 40 DAS and control. The test herbicides were sprayed as early post-emergence (2-3 leaf stage) with the spray volume of 500 liters/ha using knapsack sprayer with flood jet deflector WFN 040 nozzle. All the other recommended agronomic and plant protection measures were adopted to raise the crop and the intercultural practices were taken as need based. The data on weed counts and dry matter production (DMP) were recorded at 30 days after application (DAA) and weed control efficiency (WCE) of different treatments was computed using data on weed DMP. The leaf chlorophyll content was quantified by using a chlorophyll meter (Minolta SPAD 502) at 15, 30, 45, 60, 75 and 90 DAS. The data were analyzed following analysis of variance (ANOVA) technique and mean differences were adjusted by the multiple comparison test (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Effect on weeds

Metamifop 10 EC at 125 g/ha at 2 - 3 leaf stage recorded the lowest grassy weed density (15.7 and 10.9 in 2014 and 2015, respectively) (Table 1) and it was comparable with metamifop 100 g/ha and cyhalofop-butyl 80 g/ha. The above dosages reigned superior in weed control than the lower dose of metamifop 75 g/ha and higher dose of cyhalofop-butyl 00 g/ha. The hand weeding plots recorded the lowest weed density (14.3 and 10.1) during 2014, 2015, respectively. Unweeded control recorded the highest total weed density. The control of the grasses by the metamifop treatments and the cyhalofop-butyl has shown the corresponding similar trend in the total weed density (Table 1).

The twice hand weeding recorded the lowest grassy weed dry weight in both crop seasons. Among the herbicide treatments, lower grassy weed dry weight was recorded with application of metamifop 125 g/ha at 2 - 3 leaf stage followed by metamifop 100 g/ha and cyhalofop-butyl 80 g/ha, which were comparable with each other (Table 1). While the unweeded control treatment recorded higher grass weed dry weight.

During both the seasons, hand weeding plots registered highest weed control efficiency of 92.1 and 93.4% in 2014, 2015, respectively (Table 1). This finding was of agreement with Adhikary and Ghosh (2014). Among the herbicides, higher weed control efficiency was recorded with application of metamifop 125 g/ha followed by metamifop 100 g/ha and cyhalofop-butyl at 80 g/ha, which remained comparable with each other. The above three treatments gave significantly higher weed control efficiency than the lower dose of metamifop 75 g/ha and higher dose of cyhalofop-butyl 100 g/ha.

Effect on leaf chlorophyll content

Different doses of herbicide treatments had significant effect on leaf chlorophyll content in two season's trial for all these observation dates. The highest value was obtained with application of metamifop 125 g/ha followed by cyhalofop-butyl 80 g/ha and metamifop 100 g/ha in respective of observation dates. The lowest leaf chlorophyll content was recorded in control plots (Table 2). The chlorophyll content value obtained in the hand weeded plots was statistically similar to those obtained for herbicide treated plots. Higher yield in weed free plots or different herbicide treated plots may be attributed to their efficiency of weed control resulting in higher photosynthetic capacity as reflected by high SPAD value. The SPAD meter provides a very easy, swift and non destructive method for estimating relative leaf chlorophyll content. Higher SPAD values indicate greener and healthier plants. In this study, the SPAD values for the weedy plots were lower than the weed free treatments. It was further noticed that the SPAD value of the herbicide treated plots significantly varied from that of weed free plots. Moreover, in some cases the SPAD values of the herbicide treated plots were higher than that of weed free plots indicating healthier plants in the herbicide treated plots. This result suggested that the herbicide application does not create negative impact on leaf chlorophyll content and photosynthesis of rice crop (Suria *et al.* 2011). The lower SPAD value is associated with high weed interference resulting in yield decrease in aerobic rice (Anwar *et al.* 2010).

Effect on growth parameters

Results on plant height as affected by herbicide rates (Table 2). Data indicated that metamifop application irrespective of rates contributed to taller plants as compared to cyhalofop-butyl treated plots.

Table 1. Effect of herbicides on total grass count, weed dry weight and weed control efficiency in aerobic rice

Treatment	2014			2015		
	Total grass count (no./m^2)	Weed dry weight (g/m^2)	Weed control efficiency (WCE %)	Total grass count (no. /m^2)	Weed dry weight (g/m^2)	Weed control efficiency (WCE %)
Metamifop 75 g/ha	5.7 (31.2)	4.3 (17.8)	77.1	5.1 (25.0)	3.8 (13.6)	80.3
Metamifop 100 g/ha	4.4 (18.6)	2.9 (7.6)	89.1	3.9 (14.1)	2.7 (6.1)	91.1
Metamifop 125 g/ha	4.1 (15.7)	2.6 (5.8)	91.5	3.4 (10.9)	2.5 (5.1)	92.6
Cyhalofop-butyl 80 g/ha	4.5 (19.1)	3.0 (8.0)	88.4	3.9 (14.1)	2.7 (6.3)	90.8
Cyhalofop-butyl 100 g/ha	5.8 (32.4)	4.1 (15.8)	74.3	4.9 (23.6)	3.5 (11.6)	83.2
Two hand weeding at 20 and 40 DAS	3.9 (14.3)	2.5 (5.5)	92.1	3.3 (10.1)	2.4 (4.6)	93.4
Control	9.3 (85.7)	8.4 (69.1)	0	9.0 (79.6)	8.4 (69.2)	0
LSD (P=0.05)	0.64	0.51	-	0.58	0.50	-

*Data in the parentheses are original value; ** Square root transformed value of $(\sqrt{x+1})$ was used for statistical analysis

It might be due to the fact that metamifop treatment at early crop growth stages suppressed weed population effectively which resulted in higher vigour and growth of rice plants. Plant height increased in hand weeding plots even better than in metamifop treated plots.

First flowering was noticed to be induced slightly earlier in metamifop treated plots as compared to cyhalofop-butyl treated plots (Table 3). Similar trend was noticed in case of days to 50% flowering. However, the difference was not considerable with hand weeding plots as well as unweeded treatments. Maturity, however, came slightly earlier in metamifop treated plots compared to cyhalofop-butyl treated ones. However, the differences among the treatments were non-significant. These inferences are supported with the work of Bari (2010) who obtained varying level of tillers dynamics, plant height and phenology with the use of herbicides.

Yield attributes and yield

During both the seasons, significantly, highest numbers of panicles/m^2 (274.16 and 285.12 in 2014, 2015, respectively) were recorded with hand weeding plots which remained as compared with metamifop 125 g/ha (252.67 and 262.54 in 2014 2015, respectively). This was followed by metamifop 100 g/ha and cyhalofop-butyl 80 g/ha treatments (Table 4). Lower number of panicles/m^2 was observed in unweeded control. There was no significant difference in the test weight (1000 grain weight) of grains observed between the treatments during both seasons.

Data on grain yield revealed that in *Kharif* 2014, metamifop application contributed better than cyhalofop-butyl (Table 4). The highest grain yield 3.469 t/ha was harvested in the hand weeding treatment being followed by 3.425 t/ha in the treatment where metamifop was applied at 125 g/ha. Among the cyhalofop-butyl treatments, the highest grain yield of 3.409 t/ha was contributed by cyhalofop-butyl 80 g/ha. metamifop at 75 g/ha and higher dose of cyhalofop-butyl at 100 g/ha treatments contributed to higher grain yields over control plots, however, much lower than the hand weeded plots and rest three chemical treatments. Similar trend of observations were recorded in *Kharif* 2015. The increase in rice grain yield with efficient weed control treatments may be attributed to better crop growth due to reduced weed-crop competition for any of the growth factor. The present findings are corroborated with the previous work of Nithya *et al.* (2012), who observed that weed infestation of 100-200 weeds/m^2 reduced paddy yield by 51-64% compared with weed-free conditions. Rice plots without such competition recorded higher number of productive tillers over control because of the greater space capture by rice plants. The canopy closure occurred earlier due to

Table 2. Effect of herbicides on leaf chlorophyll content of aerobic rice (pooled over two seasons)

Treatment	Plant height (cm)	Leaf chlorophyll content					
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Metamifop 10 EC 75 g/ha	76.7	24.1	33.8	35.0	39.5	42.3	43.9
Metamifop 10 EC 100 g/ha	81.5	24.8	34.0	35.7	40.0	42.9	44.0
Metamifop 10 EC 125 g/ha	89.3	27.1	37.7	37.5	43.1	45.0	46.4
Cyhalofop-butyl 10 EC 80 g/ha	86.9	26.9	36.0	37.0	42.2	44.0	44.8
Cyhalofop-butyl 10 EC 100 g/ha	79.5	24.2	34.4	36.4	40.0	42.3	43.9
Two hand weeding at 20 and 40 DAS	88.8	25.0	33.2	35.1	39.9	43.1	44.3
Control	70.8	22.3	26.4	27.8	32.7	34.2	35.1
LSD (P=0.05)	2.4	1.0	1.1	1.0	1.2	1.4	1.6

Table 3. Effect of herbicides on phonological events of aerobic rice (pooled over two seasons)

Treatment	Days				
	1st flowering	50% flowering	Difference between 1st and 50% flowering	Maturity	Difference between 1st flowering and maturity
Metamifop 10 EC 75 g/ha	69.7	74.7	5.00	108	38.3
Metamifop 10 EC 100 g/ha	69.8	74.3	4.53	109	38.9
Metamifop 10 EC 125 g/ha	70.5	74.5	4.00	107	36.8
Cyhalofop-butyl 10 EC 80 g/ha	70.0	76.0	6.00	109	38.7
Cyhalofop-butyl 10 EC 100 g/ha	70.3	75.5	5.17	108	38.0
Two hand weeding at 20 and 40 DAS	70.5	75.3	4.83	110	39.8
Control	67.0	72.0	5.00	110	43.0
LSD (P=0.05)	NS	NS	NS	NS	NS

Table 4. Effect of herbicides on yield attributing parameters of aerobic rice

Treatment	2014			2015		
	No. of panicles/ m^2	Test weight (g)	Grain yield (t/ha)	No. of panicles/ m^2	Test weight (g)	Grain yield (t/ha)
Metamifop 75 g/ha	181	22.8	3.17	196	24.1	3.09
Metamifop 100 g/ha	239	23.8	3.42	240	24.6	3.37
Metamifop 125 g/ha	253	24.3	3.42	262	23.9	3.41
Cyhalofop-butyl 80 g/ha	226	23.1	3.41	232	24.1	3.33
Cyhalofop-butyl 100 g/ha	196	24.8	3.18	204	24.3	3.11
Two hand weeding at 20 and 40 DAS	274	23.3	3.47	285	24.0	3.40
Control	127	24.7	2.10	133	24.5	1.92
LSD (P=0.05)	17	NS	0.22	15	NS	0.24

better competitive ability and nutrient efficiency. Mahajan *et al.* (2009) concluded that herbicides are the most effective means of securing rice yields against weeds. Data indicated that in 1st year *i.e.* 2014, metamifop treated plots contributed to yield increase ranging from 50.71% to 62.94% with an average value of 58.89% over the control plots, while the respective increase in yield for cyhalofop-butyl was 62.17%. Whereas in 2015, the metamifop and cyhalofop-butyl treated plots contributed 70% and 67% grain yield, respectively, over control. But in both years maximum grain yield *i.e.* 65.03% (2014) and 76.66% (2015) were recorded in hand weeding treatment. The findings were not out of new in that similar findings have been reported by Nithya *et al.* (2012). Reason for the better yield advantage in all the weed control treatments implementing is traceable to reduction in weed competition. Data further revealed inclining trends in yield increase with the increase in metamifop rate, although yield was in declining trend when concentration crossed the recommended dose of cyhalofop-butyl. These findings were further supported with the work of Daniel *et al.* (2012). Nithya *et al.* (2012) found better yields in aerobic rice with the application of metamifop 125 g/ha. From data presented it might reasonably be argued that early post-emergence herbicides offered early season weed control up to the period of full canopy cover by rice plants, which might also contributed to higher grain yield. Application of metamifop at lower dosages could not bring the desired benefits as weeds grew luxuriantly and competed with the crop for resources like nutrients, solar radiation, water and space.

Application of metamifop at 125g/ha at 2-3 leaf stage could be the possible alternative options for effective and economic weed control in rice under aerobic system towards avoiding development of herbicide resistance in weed. The selected herbicide could be used in rotation for sustainable weed management and to run the aerobic rice system as a profitable business venture.

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