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Management of water cabbage [*Limnocharis flava* (L.) Buchenau] using new generation herbicides

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ABSTRACT

A field experiment was conducted during *rabi* season of 2011-2012 at College of Agriculture, Vellayani, Kerala, India to evaluate three promising new generation herbicides for managing water cabbage. The experiment was laid out in randomized block design with eight treatments replicated thrice. The treatments comprised of Azimsulfuron @ 20 and 30 g/ha, bispyribac-sodium @ 20 and 30 g/ ha, (metsulfuron-methyl + chlorimuron-ethyl) @ 4 and 6 g/ha, 2-4 –D @ 1 kg/ha and a weedy check. The results of the field study on weed control efficiency of the different herbicides indicated that 2, 4-D @1 kg a.i. ha^{-1} was most effective for controlling water cabbage. Among the new generation herbicides (metsulfuron methyl + chlorimuron ethyl) @ 6 g a.i. ha^{-1} and bispyribac sodium @ 30 g a.i. ha^{-1} were equally effective for controlling water cabbage. Azimsulfuron at both doses were found to be least effective in controlling water cabbage.

Key words: New generation herbicides, Phytotoxicity, Weed control efficiency.

INTRODUCTION

Water cabbage [*Limnocharis flava* (L.) Buchenau], an aquatic invasive alien weed was introduced as an ornamental plant in India. It has invaded vast tracts of low lying wetland system in Kerala and has become a serious threat to paddy cultivation. The options for managing water cabbage at present include ploughing down, manual uprooting, and the use of selective herbicides like 2,4-D. With the explosive increase in labour cost and difficulty in labour availability, rice farmers have started replacing manual weeding with herbicides. However, Nakyama *et al.* (1999) reported that *Limnocharis flava* in Malaysian agricultural rice fields was not killed by the application of 2,4-D as it became resistant due to continuous use in Malaysia. Despite the obvious advantages of herbicides, their use has also raised concerns relating to human health and the environment**.** Therefore, to identify and screen new herbicides that are economically viable and ecologically safe has become the need of the hour. The new generation of herbicides are much more environment friendly, controlling weeds with grams of active ingredients per hectare as opposed to kilograms per hectare required for the older herbicides like 2,4-D. Low use rates of these new generation herbicides allow farmers to achieve higher yields while applying 95 - 99 per cent less herbicides to their crops (Kathiresan, 2001). With this background, the present study was undertaken to identify promising new generation herbicides for managing water cabbage.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* season of 2011-2012 at College of Agriculture, Vellayani, Kerala, India to evaluate three promising new generation herbicides for managing water cabbage. The site chosen for the experiment was thickly infested with water cabbage and was left fallow. The soil of the experimental field was sandy clay loam in texture having pH 6.2, organic carbon 1.14% and available N, P and K 310.50, 26.40 and 183.10 kg ha^{-1} respectively. Rice fallow thickly infested with water cabbage was ploughed down, puddled as in the case of wetland rice and a wait period was given for uniform regrowth. The experiment was laid out in randomized block design with eight treatments replicated thrice. The treatments comprised of Azimsulfuron @ 20 and 30 g/ha, bispyribac-sodium @ 20 and 30 g/ ha, (metsulfuron-methyl + chlorimuron-ethyl) @ 4 and 6 g/ha, 2-4 –D @ 1 kg/ha and a weedy check. The herbicide spray solution in water was prepared as per the treatments and was sprayed uniformly over the weed foliage when maximum number of water cabbage plants was at 2 to 3 leaf stage. Care was taken to ensure uniformity in spraying and to avoid drift.

Azimsulfuron was applied to field retaining 8 cm of standing water and the water level was maintained for five to seven days after herbicide application. Bispyribac-sodium was applied to field having 2-3 cm of standing water and the water level was maintained thereafter. The water was drained out from the field before application of metsulfuron-methyl + chlorimuron-ethyl and was reflooded 3 days after herbicide application and maintained a standing water of 3-4 cm. The field was drained before 2,4-D application and was reflooded 48 hours after herbicide application and thereafter water level was maintained at 3-4 cm.

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The treated plots were observed closely and the visual symptoms of herbicide phytotoxicity were recorded. The weed regrowth pattern and the effect of herbicides on associated weed flora were also carefully noted. The observation on weed dry weight was repeated at 15, 30, 45 and 60 days after herbicide application using an iron quadrat of 50 cm x 50 cm placed randomly at three different places in each plot. Weeds falling within the frames were collected and separated into water cabbage and other weeds, washed, dried in shade, oven dried at 70 ± 5°C to a constant weight, and the dry weight was expressed in g/m^2. The weed control efficiency (WCE) was also calculated using the following formulae (Upadhyaya and Sivanand, 1985).

$$WCE = (X-Y) / X \times 100$$

X= Weed dry weight from treatment which recorded maximum number of weeds

Y= Weed dry weight from the treatment for which WCE must be worked out.

RESULTS AND DISCUSSION

Yellowing of leaves was the earliest and first observed visual symptom of herbicide phytotoxicity in water cabbage when treated with azimsulfuron. On three days after spraying (DAS), plants at 2-3 leaf stage were found completely yellow. At 5 DAS, the affected plants started decaying, wherein the leaf petiole got separated out and at 7 DAS, the entire plants including the roots turned into an undistinguishable mass. The larger plants also showed similar symptoms but yellowing and decaying were slower in them. At 10 DAS, fresh plants were found emerging out in plots treated with azimsulfuron @ 20 g/ha and covered the entire field. However, in plots treated with higher dose (30 g/ha) of azimsulfuron, some of the freshly emerged plants were found chlorotic and exhibited poor growth. In azimsulfuron treated plots, *Marsilea quadrifolia* also showed yellowing and browning and dried off completely within one week but regrowth was observed by third week under the lower dose. *Commelina diffusa* remained unaffected throughout the study. *Isachne miliacea* emerged as the dominant weed in the treated plots by 60 DAS.

When water cabbage was treated with bispyribac-sodium, interveinal chlorosis was the initial symptom of phytotoxicity and was visible only by 5 DAS. At 7 DAS it turned yellow and the leaf margins became necrotic and curled towards the mid rib while most of the younger plants remained unaffected. Later the affected plants decayed out completely. The few larger plants in the field expressed visual symptoms slowly but the symptoms were in similar lines and withered off with purplish discoloration by 10 DAS. Here again regrowth of water cabbage was observed at 15 DAS which was more under the lower dosage. *Commelina diffusa* and *Monochoria vaginalis* were the other weeds affected by this herbicide application while *Isachne miliacea* and *Cyperus sp.* remained unaffected and later the entire field was invaded by *Isachne miliacea*.

The phytotoxic symptoms started as interveinal chlorosis when water cabbage was treated with metsulfuron-methyl + chlorimuron-ethyl mixture. Plants at all growth stages developed interveinal chlorosis by second day itself @ 6 g/ha while at lower dose (metsulfuron-methyl + chlorimuron-ethyl @ 4 g ha^{-1}), plants at 2-3 leaf stage only showed visual symptoms. Later the leaf margins became necrotic and curled towards the mid rib and withered off with a purplish discoloration. The affected plants showed decaying symptom at the bottom portion of leaf petiole and shed off. At 5 DAS, the whole plant including the root decayed out completely and turned into an undistinguishable mass. The 2-3 leaf stage was found to be the most susceptible stage. At 10 DAS, water cabbage seedlings were found emerging out in plots applied with both the rates. However, under high dose, the emerged seedlings showed interveinal chlorosis with stunted growth at 20 DAS, most of the fresh weed flush was seen uprooted and floating in the field and later they decayed off completely. In metsulfuron-methyl + chlorimuron-ethyl treated plots *Monochroia vaginalis showed wilting symptoms followed by necrosis and were destroyed, while Isachne miliacea* remained unaffected.

The visual symptoms of phytotoxicity caused by the tested sulfonylurea herbicides were similar to the earlier observations of Vencill (2002) who reported that the sulfonylurea herbicides caused plant death by a combination of amino acid inhibition and the disruption of cell division. The symptoms were reddening of midrib and veins, wilted leaves, chlorosis, and necrosis that first appeared in the meristematic regions. Damage often appeared as root stunting and pruning due to the meristematic region being affected.

In 2,4-D treated plots, epinastic symptoms started appearing at all the growth stages of water cabbage from the next day of herbicide application. Later yellowing started from the tip of younger leaves and proceeded towards the base, followed by necrosis. In older plants, interveinal chlorosis was observed along with epinasty and later the entire leaves turned yellow, and the leaf tips started drying up. At 3 DAS, the whole foliage decayed off. Roots also decayed off and at 5 DAS, 2,4-D treated plots were completely free of water cabbage. 2,4-D was found effective in controlling water cabbage at all growth stages and no regrowth was observed. In 2,4-D treated plots *Cyperus exaltatus* showed yellowing and wilting symptoms and was destroyed by 10 DAS. *Isachne miliacea, Fimbristylis miliaceae and Ludwigia parviflora* were observed in the field initially, but later was invaded by *Isachne miliacea*.

From the data on the effect of the herbicides on weed dry weight, it was evident that the conventional herbicide 2,4-D, was most efficient in controlling water cabbage. All the treated plants were killed within five days of herbicide application and no regrowth was observed

Table 1: Effect of weed management practices on weed dry weight and weed control efficiency.

Treatments	Weed dry weight (g/m^2)				Weed control efficiency (%)			
	15 DAS	30 DAS	45 DAS	60 DAS	15 DAS	30 DAS	45 DAS	60 DAS
Azimsulfuron @ 20g/ha	15.00	45.16	81.43 (9.02)	89.47 (9.45)	28.47	43.77	35.71	37.34
Azimsulfuron @ 30 g/ha	11.9	43.38	71.87 (8.47)	77.77 (8.81)	42.36	45.96	43.33	45.64
Bispyribac-sodium @ 20g/ha	8.13	25.62	26.61 (5.15)	16.51 (4.06)	60.54	68.09	79.51	85.68
Bispyribac-sodium @30 g/ha	4.18	13.27	15.92 (3.99)	9.54 (3.08)	79.83	83.44	88.01	93.93
Metsulfuron-methyl + chlorimuron-ethyl @ 4 g/ha	7.21	18.45	22.93 (4.78)	20.27 (4.50)	65.28	77	82.46	86.24
Metsulfuron-methyl + chlorimuron-ethyl @ 6g/ha	3.08	10.35	15.39 (3.92)	8.33 (2.88)	85.16	87.08	88.42	94.74
2,4-D @ 1 kg/ha	0	0	0	0	100	100	100	100
Weedy check	20.9	80.29	126.3 (11.24)	142.3 (11.92)	-	-	-	-
SE m (+)	0.96	0.97	0.14	0.18	4.28	0.97	1.48	1.29
LSD (P=0.05)	4.01	3.05	0.45	0.58	14.59	3.07	4.66	4.06

Values in paranthesis are transformed values ; DAS- Days after spraying.

recording 100% weed control efficiency. The effectiveness of 2,4-D for controlling water cabbage was also reported by Kathiresan (2001). Generally, 2,4-D is a foliage active herbicide and is used for killing the established weeds. Interestingly, in the present study, the chemical was found to inhibit, weed re-growth which indicated that the seed germination was also inhibited by the treatment. Ram and Satsangi (1963) reported that low concentrations of 2,4-D stimulated seed germination whereas higher concentrations inhibited germination partially or completely. Shaddad *et al.* (1990) also observed that failure of the treated seeds to germinate at heavy applications of phenoxyacetic acids which might be due to retarded water uptake, inhibited cell division, ceased cell elongation, disrupted cell structure and imbalanced metabolic activities which partially or completely inhibited the process of germination.

Among the new generation herbicides, metsulfuron-methyl + chlorimuron-ethyl @ 6 g/ha and bispyribac-sodium @ 30 g/ha recorded on par lower weed dry weight followed by their lower doses and were superior to weedy check at 15, 30, 45 and 60 DAS. Azimsulfuron at both doses recorded on par weed dry weight but were significantly inferior to all other treatments except weedy check. The same trend was observed in WCE also. The WCE was 94.74 % in metsulfuron-methyl + chlorimuron-ethyl @ 6 g/ha and 93.93 % in bispyribac-sodium @ 30 g/ha followed by metsulfuron-methyl + chlorimuron-ethyl @ 4 g/ha and bispyribac-sodium @ 20 g/ha at 60 DAS (Table 1.). Azimsulfuron at both doses were found to be least effective in controlling water cabbage.

CONCLUSION

Application of new generation herbicide, metsulfuron-methyl + chlorimuron-ethyl @ 6 g/ha or bispyribac-sodium @ 30 g/ha at 2-3 leaf stage was found equally effective to control water cabbage and are promising alternatives to 2,4-D. However based on economic analysis metsulfuron-methyl + chlorimuron-ethyl @ 6 g/ha could be adjudged as the most effective and economic herbicide for controlling water cabbage. *Isachne miliacea* was not controlled by any of the tested herbicides in the experiment, which warrants detailed study.

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