Short communication

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Use of post-emergence herbicides to control weeds in ramie plantation

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Ramie (*Boehmeria nivea* (L.) Gaud. is a semi-perennial herbaceous bast fibre crop which produces longest (120 mm) and strongest (40-65 g/tex) textile fibre of plant origin (Mitra *et al.* 2014). The cultivated area of ramie in the world is about 0.088 million ha with a production of 0.163 million tonnes fibre per annum, 85% of which comes from China (Mitra *et al*. 2013). In India, ramie is naturally distributed in the North-Eastern states like Asam, Arunachal Pradesh, Manipur, Mizoram, Nagaland and northern part of West Bengal but the area under the crop is meagre. The crop faces stiff competition from both annual and perennial weeds in the field as the growth rate of ramie is much slower than that of the existing weeds during the initial establishment phase or after each cutting. Traditionally manual weeding is being practiced in ramie crop but it accounts for almost 25% of total cost of cultivation (Kumar *et al.* 2015) and is very difficult also during rainy season. Sarma *et al*. (1980) reported that combined application of atrazine and paraquat at 1 kg + 2 l/ha sprayed carefully between the rows after each cutting could control the grassy weeds in ramie plantation. However, this application was unable to control the second flush of weeds and also some perennial weeds like *Imperata cylindrica* and *Cynodon dactylon* which showed significant vegetative growth afterwards. Hence, the present experiment was conducted with an aim to identify suitable herbicides for effective control of wide spectrum of weeds present in ramie crop particularly during the rainy season when the weed growth is very high.

The field experiment was conducted in a three year old ramie plantation in two successive cuttings during 2013 at ICAR-CRIJAF Barrackpore West Bengal. The soil was clay loam in texture, with medium organic carbon (0.65%), available N (295 kg/ha) and K (180 kg/ha), while the avilable P content in soil was high (35 kg/ha). The crop was grown with recommended package and practices (Mitra *et al.* 2013). After the harvesting of existing ramie on 15-06. 2013, seven weed control treatments *viz.* weed free, ethoxysulfuron 15% WDG at 20 g/ha, quizalofop-ethyl 10% EC at 40 g/ha, quizalofop-ethyl 5% EC at 60 g/ha, fenoxaprop-p-ethyl 10% EC at 100 g/ha, protected spray (only in inter row space) of glyphosate 41% SL at 1.25 kg/ha and weedy check were imposed in randomized block design with three replications. All the herbicide treatments were followed by one hand weeding (HW) at 10 days after spraying of the herbicide (DAS). Herbicides were sprayed 20 days after each cutting/harvesting of ramie when the sprouted canes attained the height of about 25 cm and almost all weeds emerged from soil. Weed population was recorded in each plot from two randomly selected quadrats (0.5 x 0.5 m) at 30 days growth stages/days after cutting.

Weed control efficiency (WCE) and weed control index (WCI) were calculated on the basis of weed population and of weed dry weight, respectively (Das 2008). Crop was harvested at 60 day age when the lower part of the canes turned light brown or coppery in colour and lower leaves became yellowish and begin to shed. The experimental data of both the cuttings were analyzed by applying the technique of 'analysis of variance' and significance was tested by variance ratio, *i.e.* F value at 5% level. Analysis of variance for weed density and dry weight was carried out after square root $\sqrt{(x+0.5)}$ transformation to normalise the data. Regression model was developed to study the relationship of fibre yield and weed dry matter to estimate the loss in fibre yield due to weed infestation.

Weed flora

A total of nine weed species were recorded in weedy plot (Fig. 1) which comprised of four grass weeds, *viz. Imperata cylindrica* L. (relative density-42-46%), *Dichanthium annulatum* (Forsk) Stapf, (10.6-13.9%), *Cynodon dactylon* (L.) Pers, (10.7%) and *Paspalum disticum* L.,(4.6-5.9 %); four broad-leaved weeds, *viz. Ageratum conyzoides* L.(6.4-8.2%), *Blumea laciniata* (Burmf) D (4.7 %)., *Amaranthus viridis* L.(1.7-5.9 %) and *Tridex procumbens L.* (1.6-3.5%) and only one sedge, *i.e. Cyperus rotundus* (8.2-12.7%) (Fig. 1).

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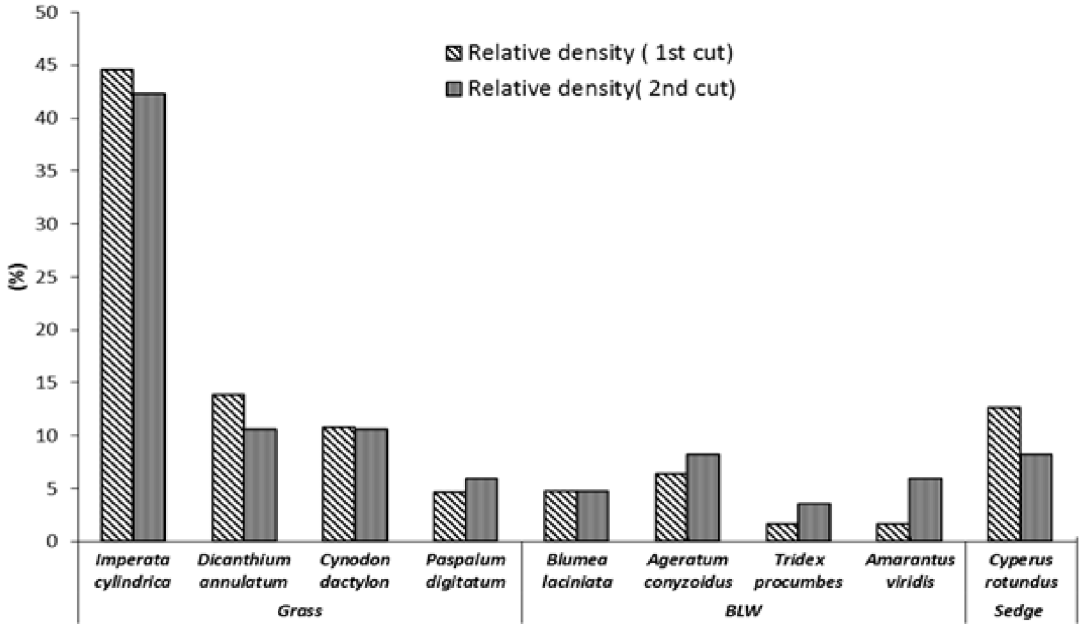

Fig. 1. Relative density of weed species in weedy plot at 30 DAS

Table 1. Effect of weed control treatment on weed density at 30 days after cutting

Treatment	Weed density (no./m^2)							
	First cut				Second cut			
	Grass	BLW	*Cyperus*	Total	Grass	BLW	*Cyperus*	Total
Ethoxysulfuron at 20g/ha + HW at 10 DASp	3.83 (15.0)	2.12 (4.0)	1.91 (3.3)	4.81 (23.0)	3.98 (16.0)	2.34 (6.3)	2.86 (8.0)	5.50 (30.3)
Quizalofop-ethyl at 40 g/ha+ HW at 10 DASp	2.86 (8.0)	2.12 (5.3)	2.12 (4.7)	4.47 (20.0)	3.33 (10.7)	3.68 (13.3)	2.39 (5.3)	5.49 (30.7)
Quizalofop-ethyl at 60 g/ha + HW at 10 DASp	3.03 (9.3)	3.12 (9.3)	2.39 (6.7)	4.84 (24.0)	3.89 (14.7)	4.00 (17.3)	2.39 (6.7)	6.17 (37.3)
Fenoxaprop-p-ethyl at 100g/ha + HW at 10 DASp	4.18 (17.3)	2.59 (6.7)	3.12 (9.3)	5.80 (33.3)	4.72 (22.7)	3.12 (9.3)	2.39 (6.7)	6.17 (38.7)
Glyphosate at 1.25 kg/ha (protected) + HW at 10 DASp	4.37 (18.7)	2.59 (6.7)	2.39 (6.7)	5.55 (30.7)	3.28 (10.7)	2.45 (8.0)	2.65 (6.7)	4.88 (25.3)
Weedy check	8.0 (64.0)	3.24 (10.7)	3.30 (12.0)	9.25 (85.3)	8.72 (76)	5.08 (25.3)	3.12 (9.3)	10.53 (110.7)
Weed free	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)
LSD (P=0.05)	1.36	1.38	NS	1.04	1.31	2.16	1.61	1.93

DASp- Days after herbicide spray; Original values in parentheses were transformed by square root transformation $\sqrt{x+0.5}$ before analysis

Effect on weeds

All the herbicides significantly influenced the density and dry weight of weeds, though, the efficacy of the herbicides varied with type of weeds *i.e.* grasses, broad-leaved weeds (BLW) and sedge (Table 1 and 2). Weed density and dry weight was found to be the highest (85.3 plants/m^2 and 41.9 g/ m^2) in weedy plot, while, the values were lowest in weed free plot at 30 DAS. Herbicide application significantly reduced both the density and dry weight of almost all types of weeds in ramie compared to the unweeded plots in both the cuttings. In the first cut, lowest weed density (24/m^2) and weed dry weight (10 g/m^2) were recorded with quizalofop-ethyl at 40 g/ha closely followed by quizalofop-ethyl at 60 g/ha treatment while in second cutting, glyphosate at at 1.25 kg/ha (protected spray) treatment was found to be most effective in reducing the density and dry weight of weeds (Table 1). Effective control of grassy weeds in ramie by spraying of quizalofop-ethyl at 60 g/ha and quizalofop-ethyl at 40 g/ha in jute had also been reported by Ghorai *et al.* (2013).

The variation in density and dry weight of broad-leaved weeds were non-significant among all the herbicides treatments during first cutting while in

Table 2. Effect of weed control treatment on weed dry weight at 30 days after cutting

Treatment	Weed dry weight (g/m^2)							
	First cut				Second cut			
	Grass	BLW	*Cyperus*	Total	Grass	BLW	*Cyperus*	Total
Ethoxysulfuron at 20g/ha + HW at 10 DASp	2.93 (8.9)	1.81 (2.8)	1.47 (2.0)	3.68 (13.2)	2.80 (7.7)	1.85 (3.6)	2.05 (4.6)	3.91 (15.1)
Quizalofop-ethyl at 40 g/ha+ HW at 10 DASp	2.05 (3.8)	1.69 (3.04)	1.59 (2.6)	3.20 (10.0)	2.36 (5.1)	3.06 (9.9)	1.79 (3.0)	4.03 (16.3)
Quizalofop-ethyl at 60 g/ha + HW at 10 DASp	2.17 (4.5)	2.38 (5.2)	1.76 (3.2)	3.50 (12.2)	2.74 (7.0)	2.82 (7.6)	1.84 (3.8)	4.46 (19.7)
Fenoxaprop-p-ethyl at 100g/ha + HW at 10 DASp	2.94 (8.32)	2.10 (4.1)	2.22 (4.9)	4.16 (16.9)	3.12 (9.4)	2.40 (5.3)	1.76 (3.4)	4.26 (17.9)
Glyphosate at 1.25 kg/ha (protected) + HW at 10 DASp	3.07 (8.9)	2.04 (3.9)	1.74 (2.6)	3.97 (15.5)	2.33 (5.1)	1.94 (4.6)	1.91 (2.3)	3.51 (12.9)
Weedy check	5.57 (30.7)	2.49 (6.0)	2.34 (5.1)	6.50 (41.9)	6.09 (36.7)	3.48 (11.7)	2.22 (7.1)	7.31 (52.9)
Weed free	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)
LSD (P=0.05)	0.88	1.01	1.09	0.69	0.80	1.57	1.06	1.38

DASp- Days after herbicide spray; Original value in parentheses was transformed by square root transformation $\sqrt{x+0.5}$ before analysis

Table 3. Effect of weed control treatment on yield attributes and fibre yield of ramie

Treatment	First cut				Second cut			
	Plant height (cm)	Basal diameter (cm)	Fibre yield (kg/ha)	Weed Index (%)	Plant height (cm)	Basal diameter (cm)	Fibre yield (kg/ha)	Weed Index (%)
Ethoxysulfuron at 20g/ha + HW at 10 DASp	92.0	0.92	395.8	21.5	77.0	0.82	379.2	19.5
Quizalofop-ethyl at 40 g/ha+ HW at 10 DASp	118.3	1.17	447.5	11.2	103.0	1.10	416.0	11.0
Quizalofop-ethyl at 60 g/ha + HW at 10 DASp	114.0	1.17	437.5	13.2	99.0	1.03	400.7	15.0
Fenoxaprop-p-ethyl at 100g/ha + HW at 10 DASp	110.7	1.10	379.2	24.8	95.7	1.00	341.7	27.4
Glyphosate at 1.25 kg/ha (protected) + HW at 10 DASp	110.0	1.13	404.2	19.8	95.0	1.03	379.2	19.5
Weedy check	79.3	0.73	258.3	48.8	69.3	0.70	229.2	51.3
Weed free	130.0	1.33	504.2	0.0	115.3	1.23	470.8	0.0
LSD (P=0.05)	15.0	0.24	77.2		15.6	0.21	90.6	

DASp- Days after herbicide spray

second cutting, the value of said parameters were found to be significantly lower in ethoxysulfuron and glyphosate treatments compared to weedy check. The same trend was observed for the density of *Cyperus rotundus* during first cut. Weed control efficiency (WCE) was the highest (76.6%) with quizalofop-ethyl treatment followed by ethoxysulfuron (73.0%) and quizalofop-ethyl (71.9%) treatments during first cutting. In the second cutting, protected spray of glyphosate 1.25 l/ha recorded highest WCE (77.1%) followed by application of ethoxysulfuron 20 g/ha (72.0%). Weed control index (WCI) was also the highest (76.0%) with quizalofop-ethyl 40 g/ha followed by quizalofop-ethyl 60 g/ha (70.9%) and ethoxysulfuron at 20 g/ha (68.4%), while in second cutting the highest WCI was recorded with protected spray of glyphosate (75.7%) followed by ethoxysulfuron (71.4%). Ethoxysulfuron had been reported to control broad spectrum weeds *i.e.* grass, BLW and *Cyperus* sp. in rice (Pal *et al.* 2008).

Lower efficacy of glyphosate during first cutting may be attributed to the fact that it was sprayed only in inter row space and hence it could not control the weeds present in the intra row space. In second cutting, regrowth of *Imperata cylindrica* and *Cyperus* was lower in inter row space (42% relative density) which resulted into comparatively higher efficacy of glyphosate during second cutting. Effective control of weeds in jute by protected spray of glyphosate was reported earlier by Ghorai *et al.* (2013)

Effect on crop

Application of all the herbicides significantly influenced the yield attributes and fibre yield of ramie.

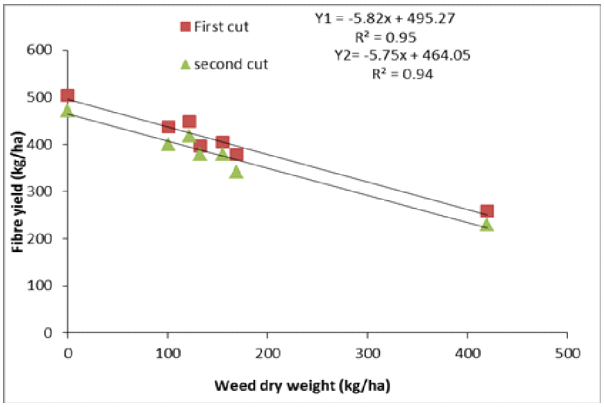

Fig. 2. Regression analysis of weed dry weight fibre yield of ramie

Maximum plant height, basal diameter and fibre yield of ramie were recorded in weed free treatment (Table 3). All the herbicide treatments, recorded significantly higher plant height and basal diameter of the crop over weedy check and maximum value of both parameters were observed in quizalofop-ethyl 40 g/ ha followed by quizalofop-ethyl 60 g/ha treatment. Fibre yield of ramie was highest with weed free treatment which was statistically at par with both the quizalofop-ethyl treatments. This was possibly due to the fact that quizalofop-ethyl alike weed free treatment effectively suppressed the growth of the dominant grassy weeds (42-46%) for a longer period and provided a less competitive environment for crop growth, which finally resulted in taller plants and higher fibre yield of ramie. Weed index was found to be maximum in unweeded plot in both the cutting (48.8 and 51.3%). A significant reduction in plant height was recorded was recorded in ethoxysulfuron 15% WDG at 20 g/ha treatment though similar trend was not observed in fibre yield of ramie both the cuttings. The results indicated a probable phytotoxic effect of ethoxysulfuron on ramie at the early stage which the crop could overcome at latter part of growth. A negative correlation was observed between weed dry weight and fibre yield of ramie (Fig. 2). The regression equation clearly showed that an increase of 1.0 kg/ha in weed dry weight resulted in decrease of fibre yield by 5.82 and 5.75 kg/ha in first and second cuts, respectively.

The results of the present study indicated that application of quizalofop-ethyl 10% EC 40 g/ha or quizalofop-ethyl 5% EC at 60 g/ha or protected spray of glyphosate at 1.25 kg/ha with one hand weeding could effectively suppress both grassy and perennial weeds in ramie and increased the fibre yield of the crop.

SUMMARY

Imperata cylindrica was the dominant grass weed (42-46%) followed by *Cynodon dactylon* (10%) and *Cyperus rotundus* (8-12%). Weed infestation throughout growing season of ramie reduced the fibre yield up to 51%. Significant reduction in weed density and dry weight was recorded in both quizalofop-ethyl at 40 g/ha and quizalofop-ethyl at 60 g/ha with weed control efficiency of 72-77% and weed index of 11-15%. The highest fibre yield was recorded in weed free treatment (470-504 kg/ha/cut) which was statistically at par with that of quizalofop-ethyl at 40 g/ha and quizalofop-ethyl at 60 ml/ha treatments (400-447 kg/ ha/cut), respectively. Significant reduction of plant height of ramie was observed in ethoxysulfuron at 20 g/ha at initial growth stage. Quizalofop-ethyl at 40 g/ ha or quizalofop-ethyl at 60 g/ha followed by one hand weeding may be applied for effective weed control in ramie.

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