Indian Journal of Weed Science (2025) **57**(3): 328–333
http://dx.doi.org/10.5958/0974-8164.2025.00056.0

RESEARCH ARTICLE

Mikania management in coffee plantation with pre- and post-emergent herbicide combinations

Atiqur Rahman Bora*[1], Jayanta Deka[2], Iswar Chandra Barua[3], Rana R. Bhuyan[3], Tasvina R. Borah[4], Hemanta Saikia[5] and Dasi Sunil Babu[6]

Received: 13 October 2024 | Revised: 11 July 2025 | Accepted: 15 July 2025

ABSTRACT

Potential yield of coffee in Northeast India is adversely affected by *Mikania micrantha* Kunth infestations. The study, conducted at Diphu, Assam during 2016 and 2017, was aimed to managing *Mikania micrantha* in coffee plantations through hastening the seed germination by soil application of gibberellic acid and killing the germinated seedlings by pre- and post-emergent herbicide application. Gibberellic acid 500 ppm significantly increased the *Mikania micrantha* seed germination, than 250 ppm, and control without any effect on the growth and yield of coffee. Oxyfluorfen 0.29 kg/ha followed by (*fb*) glyphosate 0.99 kg/ha + 2,4-D 0.73 kg/ha and oxyfluorfen 0.29 kg/ha *fb* glyphosate (0.99 kg/ha) resulted in successful management of *M. micrantha* and significantly increased the vegetative growth and yield of coffee as compared to the weedy check. Highest net return and B:C ratio during 2016-17 and 2017-18 were observed with oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha + 2,4-D 0.73 kg/ha. Next best treatment was oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha. At present, 2,4-D usage is not recommended for coffee. Therefore, oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha can be recommended for control of *Mikania micrantha* in coffee plantations.

Keywords: Coffee, 2,4-D, Economics, Glyphosate, *Mikania micrantha* Kunth, Oxyfluorfen, Weed management

INTRODUCTION

Coffee occupies an area of 479669 ha in India with an annual production of 352000 MT, accounting for 3.41% of world coffee production and 5.11% of world exports (Anonymous 2023). The coffee industry provides employment for over one million Indians earning US$ 1.28 billion as foreign exchange.

In India, coffee is grown under the canopy of forest and fruit trees and conserve bio-diversity of the coffee growing regions. In the hilly areas of Northeast India, shifting cultivation is widely practiced (0.76 million ha) by the indigenous people (Choudhury *et al.* 2016) which has rendered the land unproductive and caused environmental degradation. Coffee cultivation was introduced in this region during 1960s with the aim for stopping shifting cultivation, preservation of the fragile ecosystem and for socio-economic upliftment of the local people. (Bora and Barman 2015). At present 5647 ha area is under coffee in North East India and an additional area of 38353 ha has been identified as potential sites for coffee cultivation. Despite its great potential, the productivity of coffee is restricted to 101 kg/ha in this region (Langthasa and Bora 2013) compared to the national average of 814 kg/ha, Incidence of diseases, insect pests, and above all competitive weeds are the main reasons for the low productivity of coffee in Northeast India. Amongst these, *Mikania micrantha* Kunth is the most problematic weed, posing serious threat to successful coffee cultivation with its ability to grow over the coffee plants covering the crown and adversely affecting photosynthesis (Bora *et al.* 2023).

Mikania micrantha belonging to the family Asteraceae is an invasive perennial vine native to Central and South America (Barreto and Evans 1995). It is believed to have been introduced in Northeast India as a ground cover during World War II (Ni *et al.* 2007). Subsequently, the weed has spread to all the coffee-growing areas of the region. The Mikania plant can grow up to 47 cm in a week (Zhang *et al.* 2004) and possesses tremendous smothering ability

[1] Regional Coffee Research Station, Diphu, Assam 782461, India
[2] Girijananda Chowdhury University, Guwahati, Assam 781017, India
[3] Assam Agricultural University, Jorhat, Assam 785013, India
[4] ICAR Research Centre for NEH Region, Umiam, Meghalaya 793103, India
[5] Regional Coffee Research Station, R V Nagar, Andhra Pradesh 531133, India
[6] Technical Evaluation Centre, Coffee Board, Haflong, Assam 788819, India
* Corresponding author email: atiqurrb@gmail.com

by covering the underneath plants thereby hindering photosynthesis (Li *et al*. 2007). This weed is well adapted to the subtropical warm temperate climate of North-East India. It has the capacity of producing around 0.17 million seeds/ m^2 (Kuo 2003). These tiny seeds (0.087±0.016 g/1000 seed) are wind-dispersed over long distances, remain in the soil within 1.5 to 1.75 cm depth (Yang *et al*. 2005) and are known to persist for about 7 years in the soil seed bank (Brooks *et al*. 2008). In North-East India, seed dispersal of the weed takes place from January to March. Seed germination and emergence of vines occur whenever there is sufficient moisture in the soil at any time up to the year-end (December). The germination of *M. micrantha* seeds was reported to get enhanced with different concentrations of gibberellic acid (GA) (Nyamongo *et al*. 2009).

Due to high *M. micrantha* infestation, the coffee plantations of Northeast India suffered up to 80% yield loss (Bora, 2018). As a result, some of the coffee plantations were abandoned as the farmers could not afford the monetary loss. Control of *M. Micrantha* with pre- and post-emergence herbicides such as oxyfluorfen, glyphosate, 2,4-dichlorophenoxyacetic acid (2,4-D), diuron, paraquat, dalapon, and triclopyr are widely used in plantations. Wibowo *et al*. (2007) recommended application of glyphosate in rubber. In coffee plantations of India, glyphosate and paraquat are recommended herbicides for weed control. However, a single application of herbicide was not found to be effective against *M. micrantha* because germination of seeds and emergence take place at different times of the year depending on rainfall and soil moisture. Even though many herbicides were found suitable against *M. micrantha*, it may be a challenge to use them in the coffee plantations as coffee plant was sensitive to many of the herbicides. Post-emergence application of sulfentrazone, oxyfluorfen and lactofen imposed high injury to the young coffee plants (Ronsi and Silva 2003). Further, during the application, the drift of glyphosate impaired the growth of young coffee plants. A drift of 2,4-D caused fruit shedding in both lower and upper branches of coffee. In bearing coffee plantations, the chances of herbicide drift to coffee plants are higher as the primary and secondary branches of coffee plants spread horizontally. Hence, a detailed studies on the efficacy of herbicides in the management of *M. micrantha* in coffee plantation and their effect on the growth and yield of coffee are required before recommending the herbicides to the farmers. However, no systematic study on these aspects has been done in Northeast India.

The aim of the present study was to develop an effective management strategy for the weed *M. micrantha* and to reduce the coffee yield loss. Accordingly, a study was conducted to assess the feasibility of enhancing the germination of *M. micrantha* seeds with different concentrations of gibberellic acid (GA) and to control *M. micrantha* using selected herbicides and their combinations.

MATERIALS AND METHODS

The field study was carried out during 2016 and 2017 in coffee plantation at the Regional Coffee Research Station (25°92'N, 93°44'E, 170 m ASL) situated at Diphu, Assam, India. During the two years experimental period, the weekly mean maximum temperature ranged from 20.7° C to 35.3° C whereas weekly mean minimum temperature ranged from 6.2° C to 28.3° C. The weekly average relative humidity ranged from 85 to 96 percent during the morning hours, while in the evening hours it ranged from 47 to 82.9 percent. The total rainfall received during 2016 and 2017 were 907.2 mm and 756.2 mm respectively. The soil of the experimental site was loamy sand with a pH value of 5.06, medium in organic carbon, available nitrogen, available potassium and low in available phosphorus.

Robusta coffee (*Coffea canephora*) Selection 3R was used for the study. The coffee plants were 10 years old, planted under different shade trees (*Albizia* spp., *Acacia* spp., *Artocarpus heterophyllus* etc.) in the square system of planting at a spacing of 2.7 m x 2.7 m.

Density of *M. micrantha* in the experimental field was recorded by using quadrat (0.5m x 0.5m) at 40, 80, 120 and 160 days after GA application (DAGA) and expressed as leaf number, leaf area and dry weight in gram per square metre.

Five bearing coffee plants were randomly selected from each plot to record vegetative characters, yield attributing characters and fruit yield. The leaf area was estimated from the formula prescribed by Awatramani and Gopalakrishna (1965) and was expressed as cm^2/ plant

$$Y = K \times L \times B$$

Where, Y= estimated area (cm^2), L= leaf length (cm), B= maximum width (cm) and K = 0.65 (for robusta coffee).

The field experiment was laid out in factorial randomized block design with three replications of nine treatments consisting of three concentrations of GA, *viz*. 0 ppm, 250 ppm, and 500 ppm and herbicide application in three combinations, *viz*. oxyfluorfen

(0.29kg/ ha) followed by (*fb*) glyphosate 0.99 kg/ha, oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha + 2,4-D 0.73 kg/ha (applied separately) and weedy check. Each experimental block consisted of 25 coffee plants. GA powder (90%) w/w was diluted to 250 ppm and 500 ppm with distilled water and sprayed on the soil surface using knapsack hand sprayer with flood jet nozzle after removal of all the weeds from the plot ensuring that the soil is moistened at least to a depth of 2 cm. Pre-emergence application (PE) of oxyfluorfen 0.29 kg/ha was done on the soil surface with a knapsack sprayer and flood jet nozzle. Post-emergence application (PoE) of glyphosate 0.99 kg/ha and 2, 4-D Sodium salt 0.73 kg/ha was done targeting the foliage of *M. micrantha* in the field using a similar sprayer and nozzle. The herbicides were applied when 80% of *M. micrantha* plants attained 5-10 cm length.

Factorial randomized complete block design (RCBD) was used to analyse the response of the different treatments as well as their combinations on various parameters of the study. The statistical analysis was performed using International Business Machine (IBM) Statistical Package for Social Sciences (SPSS) version 25.0 and the graphs were prepared using Microsoft Excel 2019.

RESULTS AND DISCUSSION

In both the years of experimentation, under field conditions, the application of GA 500 ppm recorded significantly higher *M. micrantha* leaf number, leaf area, density and dry weight at 40 DAGA compared to GA 250 ppm and the check with no GA application (**Table 1** and **3**). The interaction effects of GA concentration and herbicide treatments were observed on leaf number, leaf area, density and dry weight of *M. micrantha* at 40 DAGA (**Table 2** and **4**). Significantly higher values of the vegetative parameters were recorded with the application of GA 500 ppm compared to GA 250 ppm and no GA application which might be due to the enhanced germination of *M. micrantha* seeds present in the soil as a result of GA application at higher concentrations. Along with *M. micrantha* other weed seeds i.e. *Oplismenus compositus, Sporobolus* sp. and *Cleome rutidosperma* also germinated due to GA application and were destroyed with the herbicide treatment.

In this study, oxyfluorfen 0.29 kg/ha was applied at 20 DAGA, and *M. micrantha* emergence was recorded at 40 DAGA which implied that complete eradication of the weed was not possible although the pre-emergent application of oxyfluorfen 0.29 kg/ha partially controlled the weed (**Table 1** and **3**) A similar observation was recorded by Ghosh and Ramakrishnan (1981) in a study to control *M. micrantha* in tea.

At 80, 120, and 160 DAGA, no significant difference in *M. micrantha* leaf number, leaf area and dry weight at different GA concentrations were observed (**Table 1** and **3**). Significantly higher *M. micrantha* leaf number and leaf area and dry weight were recorded in weedy plots at 40, 80, 120, and 160 DAGA as compared to other treatments (**Table 1** and **3**). Oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha and oxyfluorfen 0.29 kg/ha, followed by glyphosate 0.99 kg/ha + 2,4-D 0.73 kg/ha had successfully controlled *M. micrantha* (**Table 1** and **3**). Sellers *et al.* (2014) reported that the glyphosate caused 70% or greater control of *M. micrantha* due to its high efficacy in controlling the weed. Better result of glyphosate on controlling *M. micrantha* was also reported by Shen *et al.* (2013). The combination of glyphosate + 2, 4-D was reported to be effective for controlling *M. micrantha* in *Shorea selanica* plantations (Wibowo and Nazif 2007).

Table 1. Effect of GA concentration and herbicides treatments on *Mikania micrantha* leaf number and leaf area

Treatment	*Mikania micrantha* leaf number (no./ m^2)								*Mikania micrantha* leaf area (cm^2/ m^2)							
	40 DAGA		80 DAGA		120 DAGA		160 DAGA		40 DAGA		80 DAGA		120 DAGA		160 DAGA	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
GA concentration																
Without GA	17.6	16.2	30.9	28.9	23.8	6.0	20.0	22.2	215.9	197.7	393.6	339.7	302.0	322.2	250.1	284.1
GA 250 ppm	28.7	27.3	30.7	30.4	24.0	27.6	21.8	23.8	362.7	324.3	383.8	375.1	304.8	341.1	271.4	203.1
GA 500 ppm	36.7	38.4	32.0	32.0	27.6	28.2	22.2	24.0	452.6	457.7	397.9	374.8	349.9	349.1	276.7	306.5
LSD (p=0.05)	4.4	4.3	NS	NS	NS	NS	NS	NS	48.8	47.3	NS	NS	NS	NS	NS	NS
Herbicide																
Oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha	21.1	15.8	0.0	0.0	0.0	0.0	0.0	0.0	272.0	188.2	0.0	0.0	0.0	0.0	0.0	0.0
Oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha) + 2,4-D 0.73 kg/ha	21.6	16.7	0.0	0.0	0.0	0.0	0.0	0.0	268.8	201.8	0.0	0.0	0.0	0.0	0.0	0.0
Weedy	40.2	49.6	93.6	91.3	75.3	81.8	64.0	70.0	490.4	589.5	1175.2	1088.6	956.8	1012.4	798.2	893.7
LSD (p=0.05)	4.4	4.3	4.6	4.6	3.9	3.4	3.1	3.5	48.8	47.3	46.0	65.9	48.8	42.2	38.2	44.5
Interaction (HxG)	7.6	7.5	NS	NS	NS	NS	NS	NS	84.5	82.0	NS	NS	NS	NS	NS	NS
CV (%)	15.9	15.8	14.7	15.7	15.6	12.5	14.7	15.2	14.2	14.5	11.7	15.0	15.3	12.5	14.3	15.0

fb= followed by; S- significant: NS= Not significant

Effect on vegetative characters, yield attributing characters, and yield of coffee

In mature coffee, the vegetative and yield attributing characters like the length of the primary branch, leaf number, leaf area, number of bearing nodes in the primary branch, number of fruits per node as well as fruit and clean coffee yield were statistically at par among GA treatments in both the years of the study (**Table 5**). Amongst tested herbicide treatments, oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha and oxyfluorfen 0.29 kg/ ha *fb* glyphosate 0.99 kg/ha + 2,4-D 0.73 kg/ha caused a significant increase in vegetative characters (length of the primary branch, leaf number, leaf area), yield attributing characters (number of bearing nodes in the primary branch, number of fruits per node) and fruit yield. In comparison to weedy control, the coffee fruit yield (kg/plant) was 175% and 184 % higher in 2016 and 223% and 292% per plant in 2017 while the clean coffee yield was higher by 174% and 183% in

Table 2. Effect of GA concentration and herbicide treatments interaction on *Mikania micrantha* leaf number and leaf area at 40 days after GA application

GA concentration	*Mikania micrantha* leaf number (no./m^2) herbicides						*Mikania micrantha* leaf area (cm^2/m^2) herbicides					
	Oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha		Oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha) + 2,4-D 0.73 kg/ha		Weedy		Oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha		Oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha + 2,4-D 0.73 kg/ha		Weedy	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Without GA	8.00	7.33	6.67	8.00	38.00	33.33	97.10	89.03	82.87	97.65	467.87	406.35
GA 250 ppm	23.33	10.00	22.67	14.67	40.00	57.33	324.53	119.93	281.25	179.79	482.25	673.11
GA 500 ppm	32.00	30.00	35.33	27.33	42.67	58.00	394.36	355.73	442.27	328.12	521.17	689.17
LSD (p=0.05)	7.60	7.50	7.60	7.50	7.60	7.50	84.47	82.01	84.47	82.01	48.77	82.01
CV(%)	15.88	15.85	15.88	15.85	15.88	15.85	14.20	14.51	14.20	14.51	14.20	14.51

Table 3. Effect of GA concentration and herbicide on *Mikania micrantha* density (no./ m^2) and biomass (g/ m^2)

Factors	*Mikania micrantha* density								*Mikania micrantha* biomass							
	40 DAGA		80 DAGA		120 DAGA		160 DAGA		40 DAGA		80 DAGA		120 DAGA		160 DAGA	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
GA concentration																
Without GA	1.09	0.99	1.34	1.34	1.28	1.28	1.18	1.23	0.82	0.78	1.11	1.10	1.35	1.35	1.55	1.63
GA 250 ppm	1.23	1.15	1.36	1.36	1.29	1.30	1.20	1.25	0.85	0.82	1.13	1.12	1.37	1.37	1.58	1.68
GA 500 ppm	1.38	1.30	1.38	1.36	1.32	1.30	1.20	1.25	0.91	0.89	1.11	1.13	1.39	1.37	1.58	1.68
LSD (p=0.05)	0.12	0.13	NS	NS	NS	NS	NS	NS	0.04	0.05	NS	NS	NS	NS	NS	NS
Herbicides																
Oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha + 2,4-D 0.73 kg/ha	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Weedy	2.29	2.03	2.67	2.65	2.47	2.46	2.17	2.32	1.16	1.08	1.93	1.94	2.69	2.68	3.29	3.58
LSD (p=0.05)	0.12	0.13	0.13	0.09	0.16	0.10	0.10	0.10	0.04	0.05	0.10	0.10	0.17	0.10	0.16	0.20
Interaction (HxG)	S	S	NS	NS	NS	NS	NS	NS	S	S	NS	NS	NS	NS	NS	NS
CV(%)	9.97	11.37	9.32	6.90	12.29	7.44	8.14	8.36	4.55	6.02	8.54	8.97	12.59	7.67	10.07	11.77

fb= followed by; S- significant: NS= Not significant

Table 4. Effect of GA concentration and herbicides interaction on *Mikania micrantha* density and biomass at 40 days after GA application

GA concentration	*Mikania micrantha* density (no./m^2)						*Mikania micrantha* biomass (g/m^2)					
	Oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha		Oxyfluorfen (0.29 kg/ha) *fb* glyphosate 0.99 kg/ha + 2,4-D (0.73 kg/ha)		Weedy		Oxyfluorfen (0.29 kg/ha) *fb* glyphosate (0.99 kg/ha)		Oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha + 2,4-D 0.73 kg/ha		Weedy	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Without GA	0.71	0.71	0.71	0.71	1.86	1.56	0.71	0.71	0.71	0.71	1.04	0.93
GA 250 ppm	0.71	0.71	0.71	0.71	2.27	2.04	0.71	0.71	0.71	0.71	1.15	1.06
GA 500 ppm	0.71	0.71	0.71	0.71	2.73	2.48	0.71	0.71	0.71	0.71	1.30	1.24
LSD (p=0.05)	0.21	0.23					0.07	0.09				
CV (%)	9.97	11.37					4.55	6.02				

2016 and 221% and 234% per ha with oxyfluorfen (0.29 kg/ha) *fb* glyphosate 0.99 kg/ha and oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha + 2,4-D 0.73 kg/ha, respectively.

Both the herbicide treatments were at par in both the years regarding the vegetative and reproductive characters of coffee. The effect of the GA application was visible up to 40 DAGA only and thereafter it disappeared. This might be the reason that no effect of soil-applied GA was observed on vegetative characters, reproductive characters, and yield of coffee plants.

In the weedy control plots, *M. micrantha* vines completely covered the canopy of the coffee plants and thus reduced leaf number and, leaf area leading to reduced photosynthetic ability which in turn adversely affected number of bearing nodes and number of fruits per node resulting in reduced fruit and clean coffee yield. Further, *M. micrantha* covering increased relative humidity and created a barrier for sunlight and wind which might have changed the microclimate to more favourable proportions for black rot fungus (*Koleroga noxia* Donk) to proliferate in *M. micrantha* infested coffee plants. The saturated atmosphere with 95-100% relative humidity, thick shade, and absence of sunlight and wind are conducive to black rot disease in coffee which manifests as blackening and rotting of infected leaves, developing fruits, and young twigs. The incidence of black rot in the weedy (control) plots of mature coffee was 22.66% (2016-17) and 20% (2017-18) during the hot humid monsoon months of June to August in both years. The disease induced significantly shorter primary branches, fewer leaves, and reduced leaf area of the coffee plants. Measurement of the incidence of black rot disease (per cent) was done based on the number of plants affected according to Daivasikamani *et al.* (2016) in the weedy plots where the disease was observed due the shift in the microclimate of the weedy plots to favourable proportions for the disease. Subsequently, a significantly lesser number of bearing nodes in

Table 5. Vegetative characters, yield attributing characters and yield of coffee as influenced by GA concentration and herbicides

Factors	Vegetative characters						Yield attributing characters						Yield	
	Length of primary branch (cm)		Leaf no. (no./ plant)		Leaf area (cm^2 /plant)		No. of bearing node per primary branch		Fruits per node (no.)		Fruit yield (kg/plant)		Clean coffee yield (kg/ha)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
GA concentration														
Without GA	145.38	160.64	1024	1064	142216	147698	13.36	14.27	19.31	17.47	1.82	1.88	483.46	500.67
GA 250 ppm	141.16	157.23	1144	1158	158787	160730	13.53	14.70	19.38	16.89	1.76	1.85	466.63	491.81
GA 500 ppm	148.48	164.81	1167	1192	162072	165495	13.53	14.73	19.13	17.18	1.77	1.89	469.58	502.89
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Herbicides														
Oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha	154.79	170.18	1245	1290	172867	179175	16.18	18.14	22.84	22.36	2.23	2.39	592.73	635.38
Oxyfluorfen 0.29 kg/ha *fb* glyphosate (0.99 kg/ha) + 2,4-D 0.73 kg/ha	152.43	168.94	1287	1362	178681	189091	16.37	18.23	23.60	23.20	2.30	2.9	611.04	661.96
Weedy	127.79	143.57	803	761	111525	105657	7.88	7.33	11.38	5.98	0.81	0.74	215.89	198.02
LSD (p=0.05)	16.55	16.75	147	129	20426	18024	2.55	2.81	2.41	2.26	0.31	0.37	82.93	97.13
Interaction (HxG)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	11.42	10.42	13.2	11.4	13.2	11.4	18.85	19.29	12.51	13.19	17.54	19.68	17.54	19.50

fb= followed by; S- significant: NS= Not significant

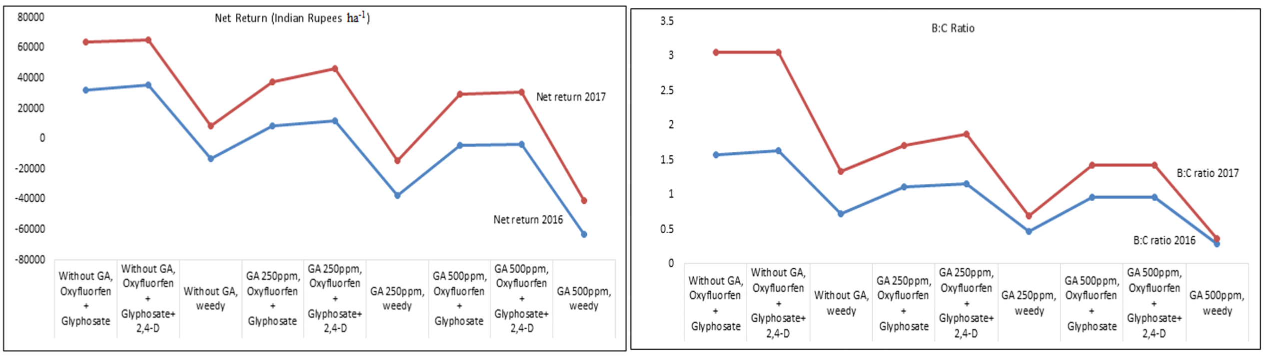

Figure 1. Economic evaluation (B:C ratio, Benefit cost ratio) of different treatments in coffee

primary branches (52% in 2016-17 and 59.8% in 2017-18) of the plants in control plots were recorded coupled with mature fruit drop of 12.22% and 10.30% inflicted yield loss of 64.66% and 70.08% in 2016-17 and 2017-18, respectively. No such yield loss was recorded in Mikania free plots. Anand *et al*. (2014) reported that during the monsoon season, prolonged soil saturation induced high levels of mature fruit drop in coffee to an extent of 20–30%. Thus, fruit drop combined with the incidence of black rot could be the major reasons for significantly fewer fruits per node of coffee plants in control plots. Better weed control due to herbicide treatments might have favoured higher leaf number, leaf area, better environment for photosynthesis, leading to more number of bearing nodes, fruits per node which ultimately produced more coffee fruits per plant.

Economics

The highest net return and highest benefit-cost (B: C) ratio (**Figure 1**) were recorded with oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha + 2, 4-D 0.73 kg/ha. This was followed by the treatments combining oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha. The lowest net return was realized in 2016-17 and 2017-18 with the combination of GA 500 ppm and weedy.

It is concluded that effective management of *M. micrantha* in the coffee plantations of North East India can be achieved by the application of either oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha) + 2,4-D (0.73 kg/ha) or oxyfluorfen 0.29 kg/ha *fb* glyphosate 0.99 kg/ha as observed by Bora et al. (2019). As 2,4-D is not permitted to be used in India, application of oxyfluorfen 0.29 kg/ha followed by glyphosate 0.99 kg/ha can be recommended for management of *M. micrantha* in coffee plantations.

REFERENCES

Anand CG, Kumar P and D'souza GF. 2014. Pre-mature fruit drop and coffee production in India: A review. *Indian Journal of Plant Physiology* **19**: 230–237.

Anonymous. 2023. Database on Coffee July 2023, Market Research and Intelligence Unit, Coffee Board of India, Bengaluru.

Awatramani NA and Gopalakrishna HK. 1965. Measurement of leaf area in coffee. *Indian Coffee* **29**(1): 25–30.

Barreto RW and Evans HC. 1995. The mycobiota of the weed *Mikania micrantha* in southern Brazil with particular reference to fungal pathogens for biological control. *Mycological Research* **99**(3): 343–352.

Bora AR, Deka J, Barua IC and Barman B. 2019. Management of Mikania micrantha in Young Robusta Coffee Plantation of Karbi Anglong District of Assam. *International Journal of Current Microbiology and Applied Sciences* **8**(03): 1004–1013.

Bora AR and Barman B. 2015. Prospects of organic coffee cultivation in North East Region of India. *Indian Coffee* **78**(2): 10–11.

Bora AR, Sunil BD, Kalita S and Chetry S. 2023. Harmful effect of the invasive weed *Mikania micrantha* with special reference to India: A review. *Agricultural Reviews* **44**(3): 380–384.

Brooks SJ, Panetta FD and Galway KE. 2008. Progress towards the eradication of mikania vine (*Mikania micrantha*) and limnocharis (*Limnocharis flava*) in northern Australia. *Invasive Plant Science and Management* **1**: 296–303.

Choudhury BU, Fiyaz AR, Mohapatra KP and Ngachan S. 2016. Impact of land uses, agrophysical variables and altitudinal gradients on soil organic carbon concentration of North-Eastern Himalayan Region of India. *Land Degradation & Development* **27**: 1163–1174.

Daivasikamani S, Ranjini AP, Raghuramulu Y. 2016. Diseases of Coffee and their management. 19–50 pp. In: *Plant Pathogens and their Management*, (Ed. Trivedi PC), Avaishkar Publishers, Distributors, Jaipur, Rajasthan, India.

Ghosh MS and Ramakrishnan L. 1981. Study on economical weed management programme in young and pruned tea with oxyfluorfen. pp. 119–125. In: *Proceedings of the Eighth Asian-Pacific Weed Science Society Conference*. (Ed. Rao BV), Bangalore. India.

Kuo YL. 2003. Ecological characteristics of three invasive plants (*Leucaena leucocephala*, *Mikania micrantha*, and *Stachytarpheta urticaefolia*) in Southern Taiwan, No. 541, Bulletins of Food & Fertilizer Technology Centre for the Asian and Pacific Region, Taipei.

Langthasa P and Bora AR. 2013. Coffee in the North eastern region-Profile of coffee in 7 sisters. Joint Director (E), North Eastern Region, Guwahati. 2 pp.

Li W, Zhang C, Gao G and Yang Z. 2007. Relationship between Mikania micrantha invasion and soil microbial biomass, respiration and functional diversity. *Plant Soil* **296**: 197–207.

Ni GY, Li FL, Chen BM, Song LY, Peng SL. 2007. Allelopathic plants: *Mikania micrantha* H.B.K. *Allelopathy Journal* **19**: 287–296.

Nyamongo DO, Nyabundi J and Daws MI. 2009. Germination and dormancy breaking requirements for *Vernonia galamensis* (Asteraceae). *Seed Science& Technology* **37**: 1–9.

Ronsi CP and Silva AA. 2003. Tolerance of coffee plants to post emergence herbicide application. *Planta Daninha* **21**: 421–426.

Sellers BA, Lancaster SR and Langeland KA. 2014. Herbicides for post emergence control of mile-a-minute (*Mikania micrantha*). *Invasive Plant Science and Management* **7**: 303–309.

Shen S, Xu G, Zhang F, Jin G, Liu S, Liu M, Chen A and Zhang Y. 2013. Harmful Effects and Chemical Control Study of *M. micrantha* H.B.K. in Yunnan, Southwest China. *African Journal of Agricultural Research* **8**: 5554–5561.

Wibowo A and Nazif M. 2007. Effectiveness of glyphosate and 2, 4- D amin herbicides to control weeds under *Shorea selanica* Bl. plantation in Carita trial garden, Banten. Indonesian. *Journal of Forestry Research* **4**: 31–43.

Yang QH, Ye WH, Deng X, Cao HL, Zhang Y and Xu KY. 2005. Seed germination eco-physiology of *Mikania micrantha* H.B.K. *Botanical Bulletin of Academia Sinica* **46**: 293–299.

Zhang LY, Ye WH, Cao HL and Feng HL. 2004 *Mikania micrantha H.B.K.* in China – an overview. *Weed Research* **44**: 42–49.