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Effect of Chemical Weed Management Practices in Ginger (*Zingiber officinale* Rosc.) under Different Inter-Cropping Systems with Cowpea

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A B S T R A C T

A field experiment was conducted during 2013-14 and 2014-15 in Assam Agricultural University, Jorhat-13. The objective of the study was to understand the effect of different chemical weed management practices in ginger under different intercropping systems. A total of 18 numbers of treatment combinations were considered, which comprised of 4 inter-cropping systems along with 4 weed management practices and 2 sole crop treatments. Cowpea in between rows of Ginger and incorporated at 40 days after sowing (DAS) recorded better results in terms of weed and crop parameters. Whereas, pre-emergence application of Metribuzin 500 g ai ha^{-1} + hand weeding (HW) at 70, 100 and 140 days after planting (DAP) recorded least weed dry weight at the initial days of peak crop weed completion and also resulted in highest rhizome yield of ginger.

Introduction

Ginger (*Zingiber officinale* Rosc.) is considered to be an important cash crop in Northeast India, accounting for 49 per cent of India`s ginger area and 72 per cent of India`s ginger production (Rahman *et al.,* 2009). Assam occupies an area of 0.07 lakh ha with a production of 0.22 lakh MT and productivity of 3286 kg ha^{-1}. However, weed is a major constraint in its production.

The most convenient approach to control weeds is the chemical method by using pre-plant and pre-emergence herbicides with the main advantage of controlling weeds before its emergence from the soil and with holding them for a considerable period of time; thus helping the crop to germinate and grow, escaping the severe competition of weeds during critical growth period to reach its potential yield and maximizing economic return. Thus, this study was undertaken with the intent to understand the impact of pre-emergence application of Metribuzin on yield and yield attributing characters of ginger.

Materials and Methods

Weather conditions during the crop growth period

A field experiment was conducted during 2013-14 and 2014-15 in Instructional cum

Research Farm of Assam Agricultural University, Jorhat. During the crop growth period of 2013-14 and 2014-15, the weekly mean maximum temperature ranged from 21.9°C to 35.1°C and 24.1°C to 33.5°C, respectively whereas weekly mean minimum temperature ranged from 8.2°C to 26.0°C and8.3°C to 26.4°C, respectively. The total amount of rainfall received during the crop growth period of 2013-14 and 2014-15 was 1921.4 mm and 1622.50 mm, respectively.

Treatment details

There were total 18 treatment combinations comprising of 4 Cropping Systems *viz.*, I_1: Ginger + Cowpea (2:1); Cowpea incorporated at 40 DAS, I_2:Ginger + Cowpea (3:1); Cowpea incorporated at 40 DAS,I_3: Cowpea in between rows of Ginger and incorporated at 40 DAS,I_4: Cowpea in between alternate rows of Ginger and incorporated at 40 DAS and 4 Weed Management Practices *viz.*, W_1:Weedy (Control), W_2:Hand weeding at 40, 70, 100 and 140 DAP,W_3: Pre-emergence application of Oxadiargyl 90 g ai ha^{-1} + hand weeding at 70, 100 and 140 DAP and W_4: Pre-emergence application of Metribuzin 500 g ai ha^{-1} + hand weeding at 70, 100 and 140 DAP, along with 2 General Control Treatments *viz.*,C_1: Ginger sole and C_2: Cowpea sole.

Raw materials

Good quality rhizomes of *Nadia* variety of ginger were treated with Mancozeb @ 3.0 g kg^{-1} rhizome and planted in a spacing of 60 cm between two rows and 25 cm between rhizomes.

The ginger rows were adjusted as per the row ratios in the cropping system treatments. UPC-278, a fodder variety of cowpea was sown as an inter-crop as per the treatment requirement, and was uprooted and incorporated in the soil at 40^{th} day after sowing.

Herbicide application and inter-cultural operations

Pre-emergence herbicides were applied with a spray volume of 500 l ha^{-1}on the 3^{rd}day after planting of ginger rhizomes. The plots were mulched with rice straw @ 4 t ha^{-1}in two splits, one immediately after planting of ginger and second at 70 DAP. Light earthing up was done at 60 and 100 DAP for ginger in all treated plots including the sole plots.

Weedy plots were left as such, with no earthing up operations. Need based plant protection measures were adopted in ginger to manage pests and diseases as per package and practices recommended by Assam Agricultural University. Before initiation of monsoon, Mancozeb was sprayed in the field with alternate cycles of Streptomycin to prevent fungal and bacterial infection.

Harvesting

In both the years, ginger crop was harvested on the 262^{nd} day after planting. From each plot, ginger rhizome was harvested by digging out with the help of spade. Soil particles attached to it were removed and fresh weight was recorded for each plot.

Results and Discussion

Cowpea biomass

In both the years 2013-14 and 2014-15, significantly higher fresh biomass weight of cowpea of 14333 and 10158 kg ha^{-1}, respectively was recorded in the treatment Cowpea in between Ginger and incorporated at 40 DAS (Table 1). Row arrangement of cowpea in this treatment might have contributed towards higher biomass. This result is in conformity with the findings of Sarma *et al.*, (1994) who reported higher yield of intercrops like greengram, blackgram and

sesame when these were sown in a row proportion of 1:2 as compared to 1:1.

Treatment with Metribuzine 500 g ai ha^{-1} pre-em + HW 70, 100 and 140 DAP recorded significantly higher fresh biomass weight of 8497 and 6958 kg ha^{-1} in 2013-14 and 2014-15, respectively (Table 1). Better weed suppression by the pre-emergence herbicide might have resulted in higher fresh yield of cowpea. Similar results are also recorded by Mishra and Jamliya (2018).

Major weed flora and relative weed density

The dominant weed flora in the experimental sites were *Elusine indica, Cynadon dactylon and Digiteria sp.* among grasses, *Cyperus iria and Fimbristylis sp.* among sedges and *Seteria sp. M. nudiflora, Alternanthera sp., Oldenlendia sp., Ageratum sp., Ludwigia sp., Phylanthus sp.*among broad leaved weeds (BLWs).

Grasses were the pre-dominant weeds recorded at all the considered intervals, in both the years (2013-14 and 2014-15). It was followed by BLWs initially. Amongst the sedges and BLWs, initially sedges were relatively low but gradually an increasing trend of sedges and vice a versa for BLWs were recorded (Fig. 1).

Weed dry weight

Weed samples collected from each treatment from sampling area of the plot at different time intervals were air dried and then oven dried at 65°± 2°C to obtain a constant weight. In 2013-14 and 2014-15, significantly less weed dry weight at 20 DAP (87 and 75g m^{-2}, respectively) and 70 DAP (206 and 174 g m^{-2}, respectively) was recorded in the intercropping treatment of Cowpea in between Ginger and incorporated at 40 DAS. At 100 and 130 DAP, least weed dry weight of 292 and 361 g m^{-2}, respectively (2013-14) and 273 and 333 g m^{-2}, respectively (2014-15) was recorded in the intercropping treatment Cowpea in between Ginger and incorporated at 40 DAS, which was *at par* with the treatment Cowpea in alternate rows and incorporated at 40 DAS (Table 2). This might be due to the fact that, in these plots cowpea density was higher in comparison to rest of the plots, which resulted in better weed suppression. Similar results on live mulching of cowpea at different densities are reported by Talebbeigi and Ghadiri (2012).

Amongst the weed management treatments, in both the years, Metribuzin 500 g ai ha^{-1} pre-em + HW 70, 100 and 140 DAP recorded significantly less weed dry weight in the initial stages i.e. 20 and 40 DAP. But at 70, 100 and 130 DAP, Metribuzin 500 g ai ha^{-1} pre-em + HW 70, 100 and 140 DAP was *at par* with Oxadiargyl 90 g ai ha^{-1} pre-em + HW 70, 100 and 140 DAP in respect of weed dry weight (Table 2). This might be due to the fact that, pre-emergence application of Metribuzin resulted in better weed suppression at the initial stages however, at later stages, the effect of the two herbicides were *at par* which might be due to their declining activity after a certain period of time. Similar result of lower weed population and weed dry weight is recorded in Metribuzin treated plots on wheat by Pandey and Verma (2002).

Plant height of ginger

At all the three considered time intervals of 100, 130 and 160 DAP, highest plant height of60.9, 94.6 and 119.4 cm, respectively in 2013-14 and 58.6, 93.5 and 114.9 cm, respectively in 2014-15 was recorded in the treatment Cowpea in between Ginger and incorporated at 40 DAS which was statistically *at par* with the treatment Cowpea in alternate rows of Ginger and incorporated 40 DAS (Table 3).

Table.1 Fresh biomass weight (kg ha^{-1}) of cowpea at the time of incorporation

Treatment	2013-14	2014-15
Cropping system		
I_1: G*+C* (2:1); C incorporated 40 DAS	4679	4523
I_2: G+C (3:1); Cowpea incorporated 40 DAS	3656	3729
I_3: C in between G; incorporated 40 DAS	14333	10158
I_4: C in alternate rows; incorporated 40 DAS	9229	7458
$CD_{P=0.05}$	448	305
Weed management		
W_1 : Weedy	7796	6196
W_2 : HW 40, 70, 100 and 140 DAP	7563	6108
W_3 : Oxadiargyl 90 g ai ha^{-1} pre-em+ HW 70, 100 and 140 DAP	8043	6606
W_4 : Metribuzine 500 g ai ha^{-1} pre-em+ HW 70, 100 and 140 DAP	8497	6958
$CD_{P=0.05}$	448	305

G*= Ginger C*= Cowpe pre-em=Pre-emergence

Table.2 Weed dry weight (g m^{-2}) at different time intervals

Treatment	20 DAP		40 DAP		70 DAP		100 DAP		130 DAP	
	2013-14	2014-15	2013 -14	2014-15	2013 -14	2014 -15	2013-14	2014-15	2013 -14	2014 -15
Cropping system										
I_1: G*+C* (2:1); C incorporated 40 DAS	138	120	166	148	372	333	492	449	577	538
I_2: G+C (3:1); Cowpea incorporated 40 DAS	148	130	176	158	325	285	431	396	506	468
I_3: C in between G; incorporated 40 DAS	87	75	114	102	206	174	292	273	361	333
I_4: C in alternate rows; incorporated 40 DAS	106	94	127	115	225	196	313	270	377	350
$CD_{P=0.05}$	14.8	14.8	14.8	9.5	18.4	15.7	21.2	18.3	22.4	21.8
Weed management										
W_1 : Weedy	172	153	196	177	579	538	734	691	841	798
W_2 : HW 40, 70, 100 and 140 DAP	177	158	203	184	202	167	290	257	356	324
W_3 : Oxadiargyl 90 g ai ha^{-1} pre-em + HW 70, 100 and 140 DAP	77	66	107	96	183	149	261	228	323	290
W_4 : Metribuzine 500 g ai ha^{-1} pre-em+ HW 70, 100 and 140 DAP	52	41	77	66	165	134	242	211	301	270
$CD_{P=0.05}$	14	14	14	9	18	15	21	18	22	21

G*= Ginger C*= Cowpea pre-em=Pre-emergence

Table.3 Plant height (cm) of ginger at different days after planting

Treatments	100 DAP		130 DAP		160 DAP	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Cropping system						
I_1: G*+C* (2:1); C incorporated 40 DAS	57.3	51.8	88.5	86.0	108.6	105.1
I_2: G+C (3:1); Cowpea incorporated 40 DAS	57.3	51.0	87.8	85.5	108.0	103.6
I_3: C in between G; incorporated 40 DAS	60.9	58.6	94.6	93.5	119.4	114.9
I_4: C in alternate rows; incorporated 40 DAS	60.4	57.7	93.9	92.3	117.6	112.6
$CD_{P=0.05}$	2.6	2.2	3.6	4.4	4.8	6.6
Weed management						
W_1 : Weedy	63.5	61.3	98.7	97.1	123.9	117.6
W_2 : HW 40, 70, 100 and 140 DAP	56.0	49.0	85.1	83.1	103.7	100.7
W_3 : Oxadiargyl 90 g ai ha^{-1} pre-em+ HW 70, 100 and 140 DAP	57.4	53.3	89.3	87.0	111.1	107.3
W_4 : Metribuzine 500 g ai ha^{-1} pre-em+ HW 70, 100 and 140 DAP	59.0	55.5	91.6	90.0	114.8	110.5
$CD_{P=0.05}$	2.6	2.2	3.6	4.4	4.8	6.6

G*= Ginger C*= Cowpea pre-em=Pre-emergenc

Table.4 Ginger leaves per clump (No. $clump^{-1}$) at different days after planting

Treatments	100 DAP	130 DAP		160 DAP		
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Cropping system						
I_1 :G*+C* (2:1); C incorporated 40 DAS	88.7	108.9	311.4	365.8	440.8	532.8
I_2 :G+C (3:1); C incorporated 40 DAS	82.1	111.0	285.6	358.8	413.1	503.6
I_3 :C in between G; incorporated 40 DAS	139.1	178.9	547.3	604.8	703.2	789.4
I_4 :C in alternate rows; incorporated 40 DAS	136.9	168.5	536.8	575.6	657.3	739.4
$CD_{P=0.05}$	5.6	8.2	8.7	32.1	28.4	32.2
Weed management						
W_1 : Weedy	32.3	30.9	59.8	60.3	94.4	95.5
W_2 : HW 40, 70, 100 and 140 DAP	110.7	153.4	434.6	501.2	571.7	668.3
W_3 : Oxadiargyl 90 g ai ha^{-1} pre-em+ HW 70, 100 and 140 DAP	137.8	169.3	520.9	584.1	691.6	828.3
W_4 : Metribuzine 500 g ai ha^{-1} pre-em+ HW 70, 100 and 140 DAP	166.1	213.7	665.8	759.5	856.6	973.1
$CD_{P=0.05}$	5.6	8.2	18.7	32.1	28.4	32.2

G*= Ginger C*= Cowpe pre-em=Pre-emergence

Table.5 Dry matter content (%)

Treatments	130 DAP		160 DAP		190 DAP	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Cropping system						
I_1 :G*+C* (2:1); C incorporated 40 DAS	26.0	27.2	47.1	48.9	58.4	60.5
I_2 :G+C (3:1); C incorporated 40 DAS	26.6	29.0	48.1	49.8	60.1	62.4
I_3 :C in between G; incorporated 40 DAS	33.5	35.9	53.2	54.5	64.6	66.4
I_4 :C in alternate rows; incorporated 40 DAS	32.9	35.0	52.2	53.7	63.8	65.5
$CD_{P=0.05}$	2.3	2.5	1.5	2.5	2.5	2.7
Weed management						
W_1 : Weedy	20.8	22.8	33.3	35.6	42.4	45.5
W_2 : HW 40, 70, 100 and 140 DAP	30.6	32.2	53.1	55.5	65.7	67.5
W_3 : Oxadiargyl 90 g ai ha^{-1} pre-em+ HW 70, 100 and 140 DAP	32.1	34.7	55.1	56.0	68.0	69.6
W_4 : Metribuzine 500 g ai ha^{-1} pre-em+ HW 70, 100 and 140 DAP	35.6	37.4	58.0	59.8	70.6	72.4
$CD_{P=0.05}$	2.3	2.5	2.6	2.5	2.5	2.7

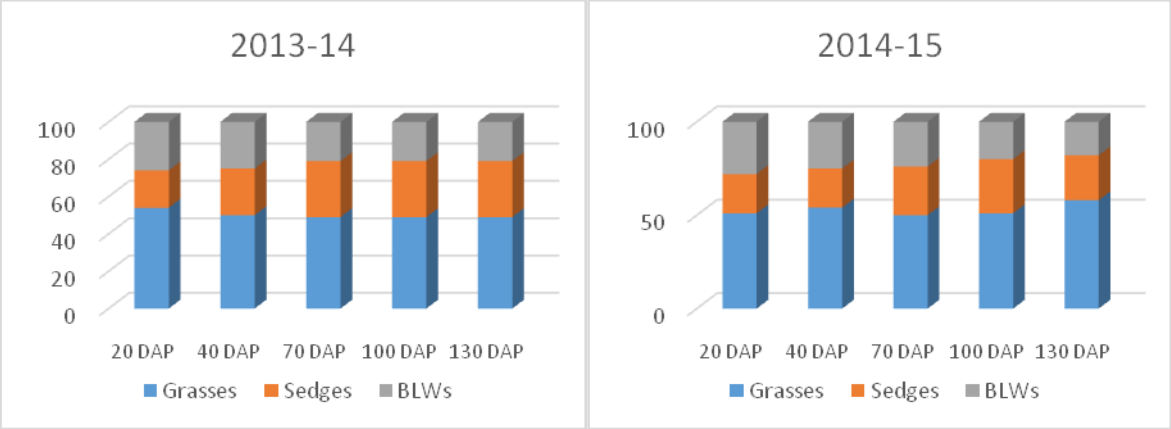
G*= Ginger C*= Cowpea pre-em=Pre-emergence

Table.6 Fresh rhizome yield (kg ha^{-1}) of ginger

Treatments	2013-14	2014-15
Cropping system		
I_1 :G*+C* (2:1); C incorporated 40 DAS	5846	6175
I_2 :G+C (3:1); C incorporated 40 DAS	5925	6454
I_3 :C in between G; incorporated 40 DAS	7542	8633
I_4 :C in alternate rows; incorporated 40 DAS	7338	8505
$CD_{P=0.05}$	419	635
Weed management		
W_1 : Weedy	5021	4825
W_2 : HW 40, 70, 100 and 140 DAP	6533	7396
W_3 : Oxadiargyl 90 g ai ha^{-1} pre-em+ HW 70, 100 and 140 DAP	7279	8208
W_4 : Metribuzine 500 g ai ha^{-1} pre-em+ HW 70, 100 and 140 DAP	7817	9340
$CD_{P=0.05}$	338	635

G*= Ginger C*= Cowpea pre-em=Pre-emergence

Fig.1 Relative weed density (%) at different time intervals



Thus, in both the years of experimentation, intercropping with Cowpea in between Ginger and incorporated at 40 DAS recorded significantly superior height of ginger. This could be due to the fact that, with more number of cowpea plants per unit area, there was better weed suppression during the critical period of competition, leading to better growth of the ginger. Similar results are recorded by Njoku and Muoneke (2008) in cassava.

The plant height was significantly higher in the weedy check at different time intervals as compared to other treatments, in both the years of experimentation (2013-14 and 2014-15). It was closely followed by Metribuzine 500 g ai ha^{-1} pre-em + HW 70, 100 and 140 DAP (Table 3). Inter specific competition between weeds and ginger for different growth factors might have resulted in vertical growth of the ginger crop. Misra and Misra (1995) also reported taller plants of blackgram in weedy plot over treated plots.

Ginger leaves

The number of leaves present in a clump was counted from 10 plants per plot, average was calculated out and expressed as ginger leaves per clump. In the first year (2013-14) at 100 DAP, highest leaves per clump of 139.1 was recorded in the cropping system of Cowpea in between Ginger and incorporated at 40 DAS which was statistically *at par* with the treatment Cowpea in alternate rows and incorporated at 40 DAS. At 130 and 160 DAP, treatment Cowpea in between Ginger and incorporated at 40 DAS recorded significantly higher number of leaves per clump of 547.3 and 703.2, respectively. Similarly in 2014-15, significantly higher leaves per clump of 178.9 and 789.4 at 100 and 160 DAP, respectively was recorded by the treatment Cowpea in between Ginger and incorporated at 40 DAS (Table 4). Thus, at all the time intervals *viz*., 100, 130 and 160 DAP in both year of study, intercropping treatment with Cowpea in between Ginger and incorporated at 40 DAP recorded the highest number of leaves per clump of ginger. Higher cowpea population might have helped better suppression of weeds in the critical crop growth stage. And Cowpea being a leguminous crop might have provided some additional nitrogen to the soil and vacated the space for ginger at 40 DAP after its harvest and incorporation.

At all the time intervals in both the years, significantly higher number of leaves per clump was recorded in Metribuzine 500 g ai ha^{-1}pre-em + HW 70, 100 and 140 DAP as compared to rest of the weed management

practices. It was followed by the treatment with Oxadiargyl 90 g ai ha^{-1} pre-em + HW 70, 100 and 140 DAP (Table 4). Very effective weed control and a longer weed free situation under Metribuzin treatment might have contributed to higher number of leaves per clump

Dry matter content of ginger

Cropping system of Cowpea in between Ginger and incorporated at 40 DAS recorded highest dry matter content at all the considered time intervals, which was statistically *at par* with the treatment Cowpea in alternate rows and incorporated at 40 DAS, in both the years of the experimentation (Table 5). Under this treatment, increased photosynthate production might have attributed to higher rate of metabolic functions contributing for increased growth by virtue of better nutrient availability and uptake by an individual plant (Singh *et al.*, 2010) which ultimately increased dry matter content.

Pre-emergence herbicide treatment, Metribuzine 500 g ai ha^{-1} pre-em + HW 70, 100 and 140 DAP recorded significantly higher dry matter content at all the time intervals in 2013-14 and 2014-15. It was closely followed by the treatment Oxadiargyl 90 g ai ha^{-1} pre-em + HW 70, 100 and 140 DAP (Table 5). A higher rate of photosynthates accumulation under a prolonged weed free environment might have contributed to higher dry matter content under this weed management treatment. Similar, results are reported by Law-ogtoma *et al.*, (2009) on Amaranthus.

Rhizome yield

Higher ginger yield of 7542 and 8633 kg ha^{-1} was recorded in Cowpea in between Ginger and incorporated at 40 DAS in 2013-14 and 2014-15, respectively over all other treatments but it was *at par* with the treatment of Cowpea in alternate rows and incorporated at 40 DAP. Better vegetative growth and higher photosynthate accumulation as indicated by higher dry matter content under these two treatments finally could have resulted higher rhizome yield in these treatments. Tewari *et al.*, (1988) reported similar findings from a study on potato (Table 6).

Ginger yield of 7817 kg ha^{-1} in 2013-14 and 9340 kg ha^{-1}in 2014-15 was recorded in the treatment Metribuzine 500 g ai ha^{-1} pre-em + HW 70, 100 and 140 DAP. It was significantly higher as compared to other weed management treatments and closely followed by Oxadiargyl 90 g ai ha^{-1} pre-em + HW 70, 100 and 140 DAP. Application of Metribuzin followed by hand weeding caused significantly better growth of ginger which might have resulted high fresh rhizome yield of ginger in this treatment.

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