Efficacy of Metamifop on weed dynamics and productivity of cotton (*Gossypium hirsutum* L.) and its residual impact on succeeding green gram (*Vigna radiata* L.)

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Abstract

Cotton is the premier commercial crop, grown mainly for its silver fibre. Its slow initial growth and heavy rainfall received during rainy months facilitate abundant population and growth of composite weeds. Due to unpredictability of rains entailing to non-workable conditions of soil and tedious, uneconomical manual weeding, chemical weed control is the viable alternative in cotton. To combat the issue, a consecutive two-year field experiment was conducted to study the efficacy of Metamifop on weed dynamics, growth and seed cotton yield of cotton and its residual impact on succeeding green gram. The experiment was laid out in randomized block design along with seven treatments namely, T_1- Metamifop 10% EC @ 800 ml/ha; T_2- Metamifop 10% EC @ 1000 ml ha^{-1}; T_3- Metamifop 10% EC @ 1200 ml ha^{-1}; T_4- Metamifop 10% EC (Std. Market Sample) @ 1000 ml ha^{-1}; T_5- Pyrithioback sodium 10% EC @ 2000 ml ha^{-1}; T_6- Hand weeding (Weed free twice) at 30 and 60 days after sowing and T_7- control, replicated thrice.

Results showed that minimum weed density, higher WCE, growth, yield attributes and seed cotton yield of cotton recorded highest under T_6 followed by T_3 and least at T_7. Among the herbicide treatments, seed cotton yield recorded highest with under T_3 (2.22 and 2.17 t ha^{-1}) followed by T_4 (2.07 and 2.09 t ha^{-1}). Highest B:C ratio was achieved under T_4 (1.44 and 1.47) followed by T_3 (1.43 and 1.46), across the years. The herbicide treatments did not show any phytotoxicity on the cotton as well as succeeding green gram. Spraying of Metamifop 10% EC showed higher efficacy at 1200 ml ha^{-1} and 1000 ml ha^{-1} as post-emergence herbicide. These treatments reinforce the potential of cotton as well as succeeding crop without affecting germination, growth and finally yield with sustainable approach.

Keywords: Cotton, Weed infestation, Post emergence herbicide, Phytotoxicity, Green Gram.

Introduction

Cotton (*Gossypium hirsutum* L.) the "Queen of fibre", is grown mainly for fibre all over the world. In India, it is grown in an area of 11.7 million hectares with a production of 39.8 million bales and productivity of 552 kg per hectare[2]. The cotton production has increased from 13.7 m bales in 2002-03 to 39.8 m bales in 2013-14 and 40.0 m bales in 2014-15[2]. Approximately 65% of India's cotton is produced on dry land and 35% on irrigated land. Except for the northern zone, which is 100% irrigated, both central and southern cotton growing zones are predominantly rainfed. Cotton, the "White Gold" enjoys premier position amongst all commercial crops in India and meet about 65 per cent requirement of the Indian textile industry.

The Indian textile industry occupies a significant place in the country's economy with over 1500 mills, four million handlooms, 1.7 million power looms and thousands of garments, hosiery and processing units, providing employment directly or indirectly to about 35 million people[6]. Textiles are India's number one export earning sector accounting for about $ 8.5 billion foreign exchange in revenue and hence cotton "Silver Fibre" plays a vital role in the economic development of the country.

Cotton is a rainy (*kharif*) season crop. It has a slow initial growth rate and receives heavy rainfall during the months of July and August providing a congenial environment for the abundant population and growth of weeds. Weed management is the most important aspect that plays an important role in exploiting the yield potential of a crop provided other inputs are not limiting. Losses due to weeds have been one of the major limiting factors of crop production. Weeds compete with crop for resources (light, moisture, nutrients etc) with early-season competition being the most critical, which is 60 days after sowing for cotton.

Weeds can also release toxins highly harmful to the crop development[3]. Thus, timely weed management is crucial for expecting higher fibre yield of cotton. Due to unpredictability of rains, entailing to non-workable conditions of soil in rainy days and non-availability of seasonal labour, manual weeding in cotton is really a challenging task[4]. Therefore, in such situations, the only alternative is the chemical weed control.

At present, several herbicide formulations are available in the market used for composites weed control. The post-emergence herbicides were found to be effective in controlling broad spectrum effectively while these herbicides are safe for environment. These herbicides have

high potency towards composites weed and are also selective to crop. In some cases, farmers also give first priority to post-emergence herbicides for controlling weeds. Considering the above fact, the present experiment was conducted to study the efficacy of Metamifop on weed dynamics, growth and seed cotton yield of cotton and its residual impact on succeeding green gram. The aim is to identify an appropriate dose of Metamifop for weed control in cotton.

Material and Methods

A consecutive two years (2021-2022) field experiment was carried out to study the 'efficacy of Metamifop on weed dynamics, growth and seed cotton yield of cotton and its residual impact on succeeding green gram' at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. The farm is geographically positioned at $26^0$19'86" N latitude, $89^0$23'53" E longitude and 43 m altitude. The experimental soil was sandy loam in texture with slightly acidic in reaction (pH 5.48), medium in organic matter content, poor bases due to high rainfall with moderate availability in primary nutrients.

The experiment was laid out in randomized block design consisting a total of seven treatments; T_1- Metamifop 10% EC @ 800 ml/ha; T_2- Metamifop 10% EC @ 1000 ml/ha; T_3- Metamifop 10% EC @ 1200 ml/ha; T_4- Metamifop 10% EC (Std. Market Sample) @ 1000 ml/ha; T_5- Pyrithioback sodium 10% EC @ 2000 ml/ha; T_6- Hand weeding (Weed free twice) at 30 and 60 days after sowing (DAS and T_7- control (Weedy Check), replicated thrice. The chemical treatments were applied at 20 DAS of cotton. However, hand weeding twice was carried out at 20 and 40 DAS.

Bio efficacy evaluation was done by recording the number of species wise weed count and total biomass of major weed flora on 1 sq. m quadrate from each plot at 15, 30 and 45 days after herbicide application (DAA). Dry weight of weeds was recorded and represented in g m^{-2}. The per cent weed control efficiency (WCE) was calculated at 15, 30 and 45 DAA based on the dry weight of individual weed using the following formula:

$$\text{WCE (\%)} = \frac{\text{WC}-\text{WT}}{\text{WC}} \times 100$$

where WC = Weed dry weight in control plot and WT = Weed dry weight in treated plot.

Experimental data on yield attributes of cotton was recorded from each plot (on 1 m^2 area basis) and yield of cotton was recorded from each plot (on net plot basis) and converted into t ha^{-1} from each herbicide treatments including plots of two hand weeded and weedy check.

Phytotoxicity observations on stunting, yellowing, necrosis, wilting, chlorosis, epinasty and hyponasty on cotton and succeeding crop green gram were recorded at 1, 3, 7, 10 and 15 days after application (DAA). The plant injury was estimated based on phytotoxicity rating scale (PRS) of 0 (no toxicity) to 10 (100% toxicity) scale. The data gathered from field experiment were analysed to study the significance of treatments effects using F test at 5% level of significance. The data collected on weeds were transformed into square root transformation ($\sqrt{x+0.5}$) for statistical analysis.

Results and Discussion

The weed flora, broad leaved (*Physalis minima, Commelina benghalensis, Phylanthus nirurii, Amaranthus viridis and Portulaca oleracea*), grasses (*Cyperus rotundus, Echinochloa colonum and Digitaria sanguinalis*) and sedges (*Cyperus rotundus* and *Cyperus iria*) were encountered infesting in the experimental field at the initial growth stage (before application of the herbicide) and during the experimentation.

Weed density: Species wise weed density was recorded at 15, 30 and 45 days after application (DAA) of herbicidal treatments (Tables 1, 2 and 3). The total weed density was lower in herbicidal treatments as compared to untreated weedy check. Among all the weed management treatments, twice hand weeding always recorded minimum weed density irrespective of days of observations and type of weed flora. Regarding the tested chemicals, T_3 Metamifop 10% EC @ 1200 ml/ha recorded minimum weed density which was statistically at par with T_2 Metamifop 10% EC @ 1000 ml/ha and T_4 Metamifop 10% EC @ 1000 ml/ha (std.). The tested chemical, Metamifop 10% EC in all the doses was found superior in controlling weeds in comparison to control.

Across all observational intervals, herbicidal treatments significantly reduced weed density compared to the untreated weedy check (T_7), demonstrating the effectiveness of chemical weed control methods. This superior performance of manual weeding is attributed to the physical removal of weeds before critical growth stages, thereby minimizing weed competition during early crop establishment. Among the chemical treatments, T_3 (Metamifop 10% EC @ 1200 ml ha^{-1}) recorded the minimum weed density, which was statistically comparable with T_2 and T_4.

The increasing dose of Metamifop from 800 to 1200 ml/ha clearly enhanced its efficacy in suppressing grass weed flora, likely due to improved foliar absorption and systemic activity. Abraham et al[1] reported that higher doses of Metamifop significantly reduced *Echinochloa crus-galli* and *Cyperus spp*. populations in direct-seeded rice.

Furthermore, Metamifop 10% EC proved more effective than Pyrithiobac sodium 10% EC @ 2000 ml ha-1 (T_5) indicating its superior selectivity and broader spectrum of weed control. These results align with the studies of Sumekar et al[9] who emphasized the efficacy of Metamifop in controlling grassy weeds with minimal crop phytotoxicity, particularly in systems where early weed emergence coincides with the vulnerable stages of crop growth. The weedy check plot (T_7) resulted in the highest

weed density throughout the crop growth stages, reaffirming the competitive advantage of weeds in the absence of management.

Weed control efficiency: Weed management treatments significantly outperformed the weedy check (T_7), demonstrating their potential in suppressing weed biomass accumulation under field conditions (Tables 4, 5 and 6). Weed control efficiency (WCE) was calculated based on weed dry weight basis of each individual treatment.

Table 1
Efficacy of Metamifop 10% EC on weed density (m^{-2}) on cotton at 15 DAA

Treatment	Weed density (m^{-2}) on cotton at 15 DAA													
	Physalis minima		***Commelina benghalensis***		***Phylanthus nirurii***		***Amaranthus viridis***		***Portulaca oleracea***		**Total grasses**		**Total sedges**	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T_1	5.7 (2.58)	5.3 (2.52)	4.0 (2.23)	4.0 (2.24)	4.7 (2.38)	4.3 (2.31)	2.7 (1.91)	2.7 (1.91)	2.7 (1.91)	3.0 (2.00)	10.0 (3.31)	10.3 (3.36)	11.3 (3.50)	11.0 (3.46)
T_2	4.7 (2.37)	4.7 (2.37)	2.7 (1.91)	3.3 (2.08)	3.0 (1.99)	3.3 (2.08)	1.7 (1.63)	1.7 (1.63)	1.3 (1.52)	2.0 (1.72)	8.7 (3.08)	7.7 (2.94)	9.7 (3.25)	9.3 (3.20)
T_3	4.3 (2.29)	4.3 (2.31)	2.3 (1.82)	2.7 (1.91)	2.7 (1.91)	3.3 (2.08)	1.7 (1.63)	1.3 (1.52)	1.3 (1.52)	1.7 (1.61)	8.7 (3.11)	7.7 (2.93)	8.0 (2.98)	8.3 (3.05)
T_4	4.7 (2.38)	5.0 (2.44)	3.3 (2.08)	3.3 (2.08)	4.3 (2.31)	3.7 (2.15)	2.3 (1.82)	2.3 (1.82)	2.3 (1.82)	2.3 (1.82)	9.7 (3.27)	9.0 (3.16)	10.7 (3.41)	10.7 (3.41)
T_5	6.3 (2.70)	5.7 (2.58)	4.3 (2.29)	4.3 (2.31)	7.0 (2.83)	6.7 (2.76)	3.7 (2.16)	3.0 (1.99)	2.7 (1.91)	3.0 (1.97)	17.0 (4.24)	17.7 (4.32)	12.7 (3.69)	12.3 (3.65)
T_6	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)
T_7	11.0 (3.46)	10.7 (3.41)	10.3 (3.36)	10.0 (3.31)	12.3 (3.65)	12.0 (3.60)	9.0 (3.16)	8.3 (3.05)	7.7 (2.94)	6.7 (2.76)	35.3 (6.03)	40.7 (6.45)	21.0 (4.69)	21.3 (4.72)
SEm±	0.13	0.08	0.13	0.07	0.09	0.10	0.09	0.10	0.08	0.13	0.12	0.08	0.18	0.12
CD (p=0.05)	0.40	0.26	0.41	0.21	0.29	0.30	0.27	0.30	0.25	0.40	0.39	0.25	0.55	0.36

Values in the parenthesis are transformed (√X+0.5) values; DAA= Days after application.

Table 2
Efficacy of Metamifop 10% ECon weed density (m^{-2}) on cotton at 30 DAA

Treatment	Weed density (m^{-2}) on cotton at 30 DAA													
	Physalis minima		***Commelina benghalensis***		***Phylanthus nirurii***		***Amaranthus viridis***		***Portulaca oleracea***		**Total grasses**		**Total sedges**	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T_1	7.0 (2.81)	6.3 (2.70)	6.3 (2.71)	5.7 (2.58)	6.3 (2.70)	7.0 (2.83)	4.7 (2.38)	5.3 (2.52)	5.0 (2.44)	4.3 (2.31)	20.7 (4.65)	19.0 (4.46)	15.0 (3.99)	14.7 (3.96)
T_2	5.7 (2.58)	5.3 (2.52)	5.3 (2.52)	4.7 (2.38)	5.7 (2.58)	5.3 (2.51)	3.0 (1.99)	3.3 (2.08)	3.3 (2.08)	3.0 (2.00)	16.3 (4.16)	15.0 (4.00)	11.0 (3.46)	10.3 (3.36)
T_3	4.0 (2.23)	5.0 (2.44)	5.0 (2.44)	4.3 (2.31)	5.3 (2.52)	5.0 (2.44)	3.0 (1.99)	2.7 (1.90)	3.0 (1.99)	2.3 (1.82)	13.3 (3.77)	13.7 (3.81)	10.3 (3.35)	10.0 (3.31)
T_4	5.7 (2.58)	5.7 (2.58)	5.7 (2.58)	5.7 (2.58)	7.3 (2.89)	6.7 (2.77)	3.7 (2.15)	4.7 (2.37)	4.7 (2.38)	3.3 (2.08)	17.3 (4.28)	16.3 (4.16)	14.7 (3.95)	13.7 (3.83)
T_5	8.7 (3.08)	7.3 (2.88)	8.7 (3.11)	7.3 (2.88)	8.7 (3.11)	8.3 (3.05)	7.0 (2.83)	6.7 (2.76)	6.7 (2.76)	5.7 (2.58)	31.3 (5.68)	29.7 (5.53)	14.7 (3.95)	15.3 (4.03)
T_6	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)
T_7	15.7 (4.08)	14.0 (3.87)	14.0 (3.87)	12.0 (3.60)	14.7 (3.96)	12.3 (3.65)	10.0 (3.31)	9.7 (3.26)	11.0 (3.46)	9.7 (3.27)	56.7 (7.58)	52.0 (7.28)	23.3 (4.93)	23.0 (4.90)
SEm±	0.16	0.11	0.10	0.07	0.11	0.10	0.12	0.12	0.11	0.07	0.18	0.13	0.17	0.13
CD (p=0.05)	0.49	0.33	0.31	0.22	0.34	0.31	0.38	0.36	0.33	0.20	0.54	0.41	0.53	0.40

Values in the parenthesis are transformed (√X+0.5) values; DAA= Days after application.

Table 3
Efficacy of Metamifop 10% EC on weed density (m^{-2}) on cotton at 45 DAA

Treatment	Weed density (m^{-2}) on cotton at 45 DAA													
	Physalis minima		***Commelina benghalensis***		***Phylanthus nirurii***		***Amaranthus viridis***		***Portulaca oleracea***		**Total grasses**		**Total sedges**	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T_1	6.0 (2.64)	5.7 (2.58)	5.3 (2.52)	5.0 (2.45)	4.7 (2.37)	4.3 (2.31)	4.7 (2.37)	5.0 (2.44)	4.7 (2.38)	4.0 (2.23)	5.0 (2.44)	5.3 (2.52)	11.0 (3.46)	10.7 (3.41)
T_2	5.0 (2.44)	4.7 (2.38)	4.0 (2.23)	4.0 (2.23)	3.7 (2.16)	4.0 (2.23)	4.0 (2.23)	4.3 (2.31)	3.0 (1.99)	3.3 (2.08)	4.7 (2.37)	4.3 (2.31)	10.0 (3.31)	9.7 (3.26)
T_3	4.0 (2.23)	4.3 (2.31)	3.3 (2.08)	3.7 (2.16)	3.3 (2.08)	3.3 (2.08)	3.7 (2.16)	3.7 (2.16)	2.7 (1.91)	2.7 (1.90)	4.0 (2.21)	4.0 (2.23)	9.3 (3.19)	8.3 (3.05)
T_4	5.7 (2.58)	5.0 (2.44)	4.3 (2.30)	4.0 (2.23)	3.7 (2.16)	4.0 (2.23)	3.7 (2.15)	3.7 (2.16)	4.3 (2.31)	3.7 (2.16)	4.0 (2.23)	4.0 (2.23)	10.3 (3.36)	10.3 (3.35)
T_5	7.7 (2.94)	7.0 (2.83)	6.0 (2.64)	5.7 (2.58)	5.7 (2.57)	5.3 (2.52)	5.7 (2.58)	6.0 (2.65)	5.7 (2.58)	5.3 (2.51)	6.3 (2.70)	5.7 (2.58)	12.7 (3.69)	11.7 (3.56)
T_6	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)
T_7	15.0 (4.00)	13.7 (3.83)	13.3 (3.78)	11.0 (3.46)	10.7 (3.41)	11.3 (3.51)	13.0 (3.74)	12.0 (3.60)	11.0 (3.46)	10.3 (3.36)	12.3 (3.65)	11.7 (3.56)	22.7 (4.85)	24.7 (5.06)
SEm±	0.10	0.10	0.10	0.08	0.10	0.10	0.13	0.08	0.11	0.11	0.17	0.06	0.18	0.15
CD (p=0.05)	0.31	0.31	0.31	0.26	0.32	0.32	0.40	0.26	0.33	0.34	0.52	0.20	0.57	0.48

Values in the parenthesis are transformed (√X+0.5) values; DAA= Days after application.

Table 4
Efficacy of Metamifop 10% EC on weed control efficiency (WCE) on cotton at 15 DAA

Treatment	WCE on cotton at 15 DAA													
	Physalis minima		***Commelina benghalensis***		***Phylanthus nirurii***		***Amaranthus viridis***		***Portulaca oleracea***		**Total grasses**		**Total sedges**	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T_1	67.7	68.4	75.9	77.8	76.2	76.6	76.1	76.1	76.1	74.3	68.9	70.3	60.8	62.6
T_2	73.2	72.0	79.0	80.1	84.0	82.8	80.7	78.1	80.8	77.6	70.7	71.9	69.9	71.2
T_3	75.4	74.9	84.0	84.7	87.1	83.7	82.8	79.2	81.7	81.4	71.4	73.1	74.8	73.7
T_4	72.3	70.1	78.0	83.5	78.8	81.5	80.1	76.0	80.5	76.9	70.1	71.0	65.5	63.2
T_5	65.0	63.5	75.7	77.3	65.2	75.5	61.8	65.0	70.4	69.9	65.7	64.0	61.2	59.8
T_6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
T_7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SEm±	2.75	2.94	1.05	1.44	1.72	1.98	2.00	1.64	2.48	2.24	2.79	2.02	1.57	1.40
CD (p=0.05)	8.58	9.16	3.27	4.49	5.37	6.16	6.22	5.09	7.72	6.97	8.70	6.29	4.90	4.37

DAA= Days after application.

Highest weed control efficiency was recorded under T_6 treatment (twice hand weeding) whereas, T_3 (Metamifop 10% EC @ 1200 ml/ha), T_2 (Metamifop 10% EC @ 1000 ml/ha) and T_4 (Metamifop 10% EC @ 1000 ml/ha) (std.) proved superiority in order to achieve higher weed control efficiency in both the years.

Highest weed control efficiency under T_6 reflects the direct and repeated outcome of physical removal of both monocot and dicot weed species before their peak growth phases, thereby minimizing their competition with the crop. Over 90% WCE observed under hand-weeded plots in transplanted rice[5], attributing it to targeted and non-selective removal of weeds during critical growth stages. The superior performance in terms of WCE of T_3 treatment is likely due to the higher application rate, ensuring improved absorption and translocation, leading to more effective suppression of grass weeds like *Echinochloa spp*. and *Digitaria sanguinalis*. Significant reductions in weed biomass and higher WCE were observed under higher dose application of Metamifop in direct-seeded rice systems[7].

The relatively lower WCE observed in T_1 and T_5 indicates suboptimal suppression of weed biomass, possibly due to inadequate dose or narrow spectrum of activity against dominant weed flora in the experimental field. When grassy weeds were most dominant, constituting 66.0-91.8% of total weed dry weight across treatments, some herbicide

combinations showed limited efficacy[7]. Overall, the experiment confirms that Metamifop 10% EC, particularly at 1000-1200 ml/ha, is effective in reducing weed biomass and enhancing weed control efficiency, offering a viable chemical alternative to labor-intensive manual weeding.

Growth, yield attributes and seed cotton yield of cotton: For this trait, the differences among the treatments were statistically significant (Table 7). Treatment T_6 (Hand weeding twice) recorded highest growth attributes, yield attributes and seed yield in both years. Among the herbicidal treatments, the maximum growth attributes and seed yield were recorded under T_3 (Metamifop 10% EC @ 1200 ml/ha) and T_2 (Metamifop 10% EC @ 1000 ml/ha) during the both the year of experimentation followed by T_4 (Metamifop 10% EC @ 1000 ml/ha) (std.). Even higher yield was observed under T_1 (Metamifop 10% EC @ 800 ml/ha) over control. In terms of Benefit-Cost ratio, T_4 reflects highest B:C ratio immediately followed by T_3, T_2, T_1, T_5, T_6 and least at T_7 (Control) in both the years.

The treatment T_6 (Hand weeding twice at 30 and 60 DAS) recorded the highest growth parameters including plant height, number of fruiting branches plant^{-1}, number of boll plant^{-1}, seed cotton yield (kg ha^{-1}) as well as maximum seed yield in both years probably due to complete removal of weed during the crop's critical growth stages, which provided a weed-free environment and ensured optimal resource availability (light, nutrients, water) for the crop throughout its growth cycle. Paul et al[5] observed significant improvements in growth and yield of rice under hand-weeded conditions compared to chemical and control treatments.

Table 5
Efficacy of Metamifop 10% EC on weed control efficiency (WCE) on cotton at 30 DAA

Treatment	WCE on cotton at 30 DAA													
	Physalis minima		***Commelina benghalensis***		***Phylanthus nirurii***		***Amaranthus viridis***		***Portulaca oleracea***		**Total grasses**		**Total sedges**	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T_1	71.8	73.9	73.9	75.2	75.3	72.3	74.4	76.0	77.8	81.1	73.4	71.3	66.7	64.7
T_2	74.8	78.3	81.5	80.6	78.5	77.2	81.0	81.2	79.7	82.8	77.7	78.1	73.9	73.8
T_3	76.1	79.0	82.2	80.9	79.6	78.6	83.5	82.4	81.2	83.4	81.2	79.4	75.5	74.8
T_4	72.6	78.0	81.2	76.3	77.9	73.3	80.3	78.3	78.6	81.9	74.4	77.3	69.5	67.3
T_5	71.3	72.7	73.4	72.9	72.1	65.8	70.4	75.4	75.4	72.8	70.0	69.2	64.7	61.0
T_6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
T_7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SEm±	2.26	0.97	0.67	1.35	1.20	1.20	1.40	1.08	1.52	1.15	1.89	1.25	1.36	3.39
CD (p=0.05)	7.06	3.03	2.08	4.22	3.74	3.75	4.35	3.35	4.74	3.58	5.88	3.89	4.23	10.56

DAA= Days after application.

Table 6
Efficacy of Metamifop 10% EC on weed control efficiency (WCE) on cotton at 45 DAA

Treatment	WCE on cotton at 45 DAA													
	Physalis minima		***Commelina benghalensis***		***Phylanthus nirurii***		***Amaranthus viridis***		***Portulaca oleracea***		**Total grasses**		**Total sedges**	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T_1	54.6	55.4	69.2	68.1	71.7	68.2	66.2	66.3	70.0	76.0	71.0	68.3	77.7	75.3
T_2	66.0	58.5	73.5	75.8	76.3	71.1	72.8	72.3	75.7	76.4	73.4	71.5	81.2	79.2
T_3	67.0	62.8	74.7	76.4	77.2	73.4	73.5	74.6	83.4	83.0	74.1	75.1	82.7	80.4
T_4	65.4	57.6	73.4	68.8	71.1	59.1	72.9	70.2	73.4	74.7	72.9	70.1	76.4	76.6
T_5	54.9	54.0	67.7	67.5	71.1	60.1	66.0	65.8	69.1	65.6	71.5	68.2	74.5	72.2
T_6	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
T_7	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SEm±	2.38	2.71	1.56	2.08	1.25	1.24	1.28	0.99	9.31	9.83	2.14	1.65	1.38	1.19
CD (p=0.05)	7.41	8.45	4.86	6.47	3.89	3.88	3.98	3.09	28.99	30.64	6.68	5.15	4.28	3.71

DAA= Days after application.

Table 7
Efficacy of Metamifop 10% EC on growth, yield attributes, yield and economics of cotton

Treatment	Plant height (cm)		Number of fruiting branches plant^{-1}		Number of boll plant^{-1}		Seed cotton yield (kg ha^{-1})		Weed index (%)		B:C ratio	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T_1	93.20	93.70	5.42	4.91	22.67	23.67	1.98	2.04	16.53	13.32	1.30	1.31
T_2	94.30	94.97	6.56	5.93	25.43	26.70	2.19	2.14	7.90	9.15	1.38	1.39
T_3	95.60	98.10	7.03	6.20	27.20	27.33	2.22	2.17	6.37	6.25	1.43	1.46
T_4	93.90	94.00	5.91	5.48	24.67	25.00	2.07	2.09	13.12	11.54	1.44	1.47
T_5	90.17	92.10	4.92	4.60	19.33	21.43	1.91	1.94	19.45	19.01	1.13	1.15
T_6	103.40	104.77	7.23	6.40	29.50	30.33	2.38	2.40	0.00	0.00	1.06	1.07
T_7	82.10	84.30	4.22	4.04	12.43	12.30	1.49	1.45	37.37	39.36	0.18	0.22
SEm(±)	1.21	1.62	0.44	0.24	1.95	2.11	0.06	0.04	2.39	1.47	-	-
CD (P=0.05)	3.77	5.05	1.38	0.75	6.07	6.59	0.18	0.11	7.44	4.57	-	-

Table 8
Residual effect of Metamifop 10% EC on succeeding green gram

Treatment	Germination %		Plant height (cm)		Number of branches plant^{-1}		No. of pod plant^{-1}		No. of seeds pod^{-1}		Seed yield (kg ha^{-1})	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
T_1	81.3	82.0	39.0	40.0	6.67	6.33	31.7	33.7	6.67	6.67	1092	1090
T_2	81.0	81.0	40.7	40.3	6.67	7.00	34.0	34.3	6.67	7.00	1108	1113
T_3	80.3	80.7	41.0	41.3	7.33	7.33	34.3	35.0	7.00	7.00	1113	1117
T_4	80.3	80.0	40.3	40.0	6.33	6.67	33.3	34.0	6.67	6.67	1093	1100
T_5	79.7	79.0	37.0	38.7	5.33	6.33	33.0	34.3	6.33	6.33	1087	1085
T_6	82.7	83.0	42.0	42.7	7.67	7.67	34.7	35.3	7.00	7.33	1123	1125
T_7	80.0	80.3	38.3	39.0	6.33	6.33	33.0	33.3	6.33	6.33	1075	1095
Sem (±)	0.59	0.83	0.79	1.08	0.35	0.45	0.99	0.61	0.46	0.44	14.53	14.85
CD (P=0.05)	NS	NS	2.46	NS	1.08	NS	NS	NS	NS	NS	NS	NS

NS = Non significant.

Among the herbicidal treatments, T_3 performed better and consistently recorded the highest growth attributes and seed yield, closely followed by T_2 and T_4. The increased efficacy of T_3 in suppressing early-season grassy weeds likely reduced crop-weed competition, particularly during the active tillering and panicle initiation stages, thereby improving physiological growth parameters and reproductive output. Treatment T_1 even at the lower dose treatment performed good over T_7 (Control) indicating suboptimal chemical application offered partial weed control and a corresponding yield advantage.

The unchecked weed proliferation under T_7 resulted in intense competition for growth resources during critical crop development phases, ultimately suppressing biomass production and seed yield. Paul et al[5] reported 15 % to 60 % yield loss in rice under severe weed infestation without any weed management intervention.

Under T_3 treatment, cost of cultivation is lower than T_6, whereas weed control efficiency, growth and yield of cotton are higher and weed density is lower under T_6 treatment and significantly least at T_7 (Control) due to higher crop weed competition during peak growth period of cotton crop.

Succeeding green gram: From the experiment, it was observed that the herbicide treatments had no phytotoxic effect on the germination, growth, yield attributes and seed yield of green gram (Table 8). It was observed that the differences among the treatments were statistically non-significant.

Phytotoxicity effect: The herbicides applied during the cotton cropping season did not exert any adverse effect on the cotton as well as succeeding green gram. All doses of Metamifop 10% EC, even at the highest tested level of 1200 ml/ha (T_3), as well as Pyrithiobac sodium 10% EC @ 2000 ml/ha (T_5), did not affect subsequent crops. This suggests rapid degradation or immobilization of the herbicides in the soil under the prevailing environmental conditions, likely aided by microbial activity, soil texture and rainfall pattern, thus preventing any residual toxicity to the succeeding green gram. The absence of phytotoxicity symptoms such as chlorosis, necrosis, stunting, or leaf deformities across

treatments was found to be biologically safe for the succeeding crop within recommended rates and timeframes.

Conclusion

It could be concluded from two seasons field experiment that spraying of Metamifop 10% EC showed higher efficacy at 1200 ml ha^{-1} and 1000 ml ha^{-1} as post-emergence herbicide. No phytotoxicity symptoms were observed with Metamifop 10% EC @ 1200 ml ha^{-1} both in cotton and succeeding green gram. These treatments reinforce the potential of cotton as well as succeeding crop without affecting germination, growth and final yield with sustainable approach.

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