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Significance of Weed Flora Identification and its Management on *Bt* Cotton (*Gossypium hirsutum* L.) Growing Tract of Tungabhadra Command Area

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Authors' contributions

This work was carried out in collaboration among all authors. The author KSS had done the methodology, formal analysis; original data recording, statistical analysis and wrote the first draft of manuscript and the protocol. The authors GSY, BMC, MYA, SNB and NN were all supported to frame the methodology, data validation, project administration and supervision. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To identify the weed species in *Bt* cotton under Tunga-bhadra project command area and to study the effect of sequential application of pre- emergent (PE) and post- emergent herbicides (PoE) on weed growth and to know the efficiency of different weed control practices on weed species.

Study Design: The experiment was laid in RBD (Randomized Block Design).

Place and Duration of Study: The experiment was conducted at ICAR-Krishi Vigyan Kendra farm, UAS, Raichur situated in TBP command area during *kharif* season of 2018-19.

Methodology: The design was RBD with 11 treatments and replicated thrice. Gross plot size of the field was 7.2 m × 4.8 m and net plot size was 5.4 m ×3.6 m with spacing of 90 x 30 cm. The certified seeds of Jadoo *Bt* II Cotton with the test weight of 6.5 g was used for sowing. The crop duration was around 6 month

Results: Weed flora present in the *Bt* cotton field were identified and classified based on their morphology. It was divulged that; dicotyledonous weeds were dominant in cotton field. The sequential applications of metolachlor 50 % EC @ 1000 g *a.i.* ha^{-1} as PE *fb* pyrithiobac sodium 10 EC @ 125 g *a.i.* ha^{-1} as PoE @ 2-5 leaf stage of weeds *fb* Inter cultivation (IC) @ 60 DAS reported lower weed count and weed dry matter and reported the highest weed control efficiency (90.22 %) at harvest than the application of diuron 80 % WP as PE *fb* @ 1500 g *a.i.* and pendimethalin Pendimethalin 30 EC @ 1250 g *a.i.* ha^{-1} as PE followed by pyrithiobac sodium 10 EC @ 125 g *a.i.* ha^{-1} as PoE @ 2-5 leaf stage of weeds *fb* Inter cultivation (IC) @ 60 DAS.

Conclusion: Application of pre-emergent followed by post emergent herbicides control the early and later flush of weeds. It avoids the emergence of broad spectrum weed flushes and weed shift. Integrated herbicidal application along with intercultural operations was found better in keeping weeds under a threshold than following a single method.

Keywords: Bt cotton; pre-emergent; weed control efficiency; Weed flora; sequential application.

1. INTRODUCTION

Bt cotton is the only GM crop permitted for cultivation in the country by Govt. of India. All four of the cultivated species of cotton, *Gossypium arboretum, G. herbaceum, G. barbadense and G. hirsutum* are grown in Karnataka on an area of 5.75 lakh ha, producing 18 lakh bales and yielding 532.17 kg lint ha^{-1} [1] *Gossypium hirsutum* accounts for the majority of the hybrid cotton grown. Bt cotton is widely grown on black soils in the state's north-eastern dry zone (Zones 2 and 3), which includes portions of the Tunga bhadra and Upper Krishna irrigation project commands (TBP and UKP). In these commands, there has been a noticeable increase in the area planted with this crop in recent years.

The losses due to weeds are immense in *Bt* cotton and being a long duration crop, it is subjected to a severe weed menace. Weed infestation in cotton has been reported to offer severe competition and causing yield reduction to an extent of 50-85 per cent. The important monocotyledonous weeds observed in TBP area were *Cyperus rotundus, Cynodon dactylon, Dinebra retroflexa, Echinochloa colonum and Echinocloa crusgalli.* While common dicotyledonous weeds observed were *Abutilon indicum, Commelina benghalensis, Digeria arvensis, Mimosa pudica, Parthenium hysterophorous, Phyllanthus fraternus, and Xanthium strumarium* [2]. With the use of a suitable herbicide, weeds in the cotton field can be effectively killed or knocked down. Hence, they are capable of giving the crop a relatively better weed free situation in the early stage of crop. Thus, the weed flora identification is very much important in knowing the selectivity and susceptibility of weeds towards the herbicides. Recent studies on sequential use of herbicides were evident that, single treatment of herbicides failed to control weeds more effectively than the former method. Hence this study was conducted to prove the effect of sequential application of herbicides on weed flora identified from *Bt* growing area [3].

2. MATERIALS AND METHODS

The experiment was conducted during kharif season of 2018-19 at ICAR- Krishi Vigyan Kendra farm, UAS, Raichur situated in TBP

command area. It was laid out in medium black soil situated in North-eastern Dry zone (Zone 2) of Karnataka at 15˚14' N latitude and 77˚07' E longtitude with an altitude of 389 meters above the mean sea level. The design was RBD with 11 treatments and three replications. Gross plot size was 7.2 m × 4.8 m and net plot size was 5.4 m ×3.6 m. The certified seeds of Jadoo *Bt* II with an average weight of of 6 to 6.5 g were used for sowing with a spacing of 90 cm × 30 cm. The sowing was done at August 16th 2018. The treatment consists of T_1-Metolachlor 50 % EC @ 800 g *a.i* ha^{-1} as PE *fb* IC @ 45 and 60 DAS, T_2 - Metolachlor 50 % EC @ 1000 g *a.i* ha-$^{-1}$ as PE *fb* IC @ 45 and 60 DAS, T_3- Metolachlor 50 % EC @ 1200 g *a.i* ha^{-1} as PE *fb* IC @ 45 and 60 DAS, T_4- Metolachlor 50 % EC @ 2000 g *a.i* ha^{-1} as PE *fb* IC @ 45 and 60 DAS, T_5- Diuron 80 % WP @ 1500 g *a.i* ha^{-1} as PE *fb* IC @ 45 and 60 DAS, T_6- Pendimethalin 30 EC @ 1250 g *a.i* ha^{-1} as PE *fb* IC @ 45 and 60 DAS, T_7-Metolachlor 50 % EC @ 1000 g *a.i.* ha-^{1} as PE *fb* Pyrithiobac sodium 10 EC @ 125 g *a.i.* ha^{-1} as PoE @ 2-5 leaf stages of weeds *fb* IC @ 60 DAS, T_8- Diuron 80 % WP @ 1500 g *a.i.* ha^{-1} as PE *fb* Pyrithiobac sodium 10 EC @ 125 g *a.i.* ha^{-1} as PoE @ 2-5 leaf stages of weeds *fb* IC @ 60 DAS, T_9- Pendimethalin 30 EC @ 1250 g *a.i.* ha^{-1} as PE *fb* Pyrithiobac sodium 10 EC @ 125 g *a.i.* ha^{-1} as PoE @ 2-5 leaf stages of weeds *fb* IC @ 60 DAS, T_{10}-Two hand weedings @ 15 and 30 DAS *fb* IC at 45, 60 and 75 DAS and T_{11}-Weedy check @ 15 and 30 DAS.

Metolachlor 50 EC, Diuron 80 WP and Pendimethalin 30 EC were applied on soil surface a day after sowing. Knapsack sprayers were utilized to apply these herbicides, and around 500 litres of water were used per hectare. Pyrithiobac sodium 10 EC was used in this experiment as post emergent. Intercultivation was carried out at 45 and 60 DAS for (T7 to T9) and at 45, 60 and 75 DAS for (T10). With the use of a blade hoe attached to bullocks, intercultivation was carried out. Only weed free checks at 15 and 30 DAS are conducted manually by hand. Three picking was done here during 6 MAP.

3. RESULTS AND DISCUSSION

3.1 Observation on Weeds

3.1.1 Weed flora

Table 1 indicating the weed flora observed in this experiment site of *Bt* cotton. The pre-dominant grass weeds in this experiment were *Agropyren repens, Brachiaria euciformis, Cyanadon dactylon, Cyperus rotundus, Dinebra retroflexa, Digitaria ciliaris, and Dinebra retroflexa.* While common broad leaved weeds observed were *Aristolochia bracteata Retz, Amaranthus spinosus, Calatropis gigantean, Commelina bengalensis, Corchorus trilocularis, Euphorbia geniculata, Euphorbia hirta, Cassia occidentalis, Cleome viscosa, Parthenium hysterophorus, Phyllanthus niruri, Xanthium strumarium, Abutilon indicum etc*.

The *Poaceae* was the most prevalent family identified in the experimental location. Species composition was not uniform in the field, still the dicotyledonous weeds were more in number and competitive with the crop. These findings were also previously reported by [4,5,6 and 2]. It was also visible that, both *kharif* and *rabi* weeds were abundant in this area as because of the soil was *vertisol*, which had favourable physio-chemical properties.

The soil characteristics particularly the amount of clay, play a major role in weed flora growth was reported formerly by [7].

3.1.2 Total weed count (m^{-2})

The total weed count at different stages of crop growth influenced by different type of herbicidal applications is depicted in the Fig. 1. The lowest weed count (2.60 m^{-2}) at 15 and (3.97 m^{-2}) 30 DAS was recorded with the application of metolachlor 50 % EC @ 2000 g *a.i* ha^{-1}as PE *fb* IC @ 45 and 60 DAS. The highest weed count (4.16 m^{-2}) at 15 DAS and (5.16 m^{-2}) at 30 DAS was identified in weedy check.

At 45 DAS, metolachlor 50 % EC @ 1000 g *a.i.* ha^{-1} as PE *fb* pyrithiobac sodium 10 EC @ 125 g *a.i.* ha^{-1} as PoE @ 2-5 leaf stages of weeds *fb* IC @ 60 DAS recorded the lower weed count after weed free treatment, two hand weeding @ 15 and 30 DAS *fb* IC at 45, 60 and 75 DAS. Other treatments were comparable and were significantly superior to weedy check.

At 75 DAS and at harvest metolachlor 50 % EC @ 1000 g *a.i.* ha^{-1} as PE *fb* pyrithiobac sodium 10 EC @ 125 g *a.i.* ha^{-1} as POE @ 2-5 leaf stages of weeds *fb* IC @ 60 DAS (T_7) had significantly lower weed count (4.86 m^{-2}) and (3.62 m^{-2}) respectively, among all other treatments.

Table 1. Classification of weeds into Grasses, broad – leaved, and sedges observed in the experimental site

Weed species	Family
Narrow – leaved weeds (Grasses)	
Cynodon dactylon (L.) Pers	Poaceae
Dinebra retroflexa (Vahl.)	Poaceae
Digitaria ciliaris	Poaceae
Brachiaria euciformis	Poaceae
Agropyron repens L.	Poaceae
Cyperus rotundus L.	Cyperacea
Broad - leaved weeds	
Cyanotis cucullata (Roth)	Commelinaceae
Euphorbia hirta L.	Euphorbiaceae
Euphorbia geniculata L.	Euphorbiaceae
Legasca mollis,	Asteraceae
Leucus aspera	Laviatae
Parthenium hysterophorus L.	Asteraceae
Phyllianthus niruri	Euphorbiaceae
Physalis minima	Solanaceae
Abutilon indicum (L.) *Sweet*	Malvaceae
Acalypha indica	Euphobiaceae
Acanthospermum hispidum	Asteraceae
Amaranthus spinosus	Amaranthaceae
Aristolochia bracteata Retz.	Aristolochiaceae
Calotropis gigantea R. Br.	Asclepiadacae
Commelina benghalensis L.	Commelinaceae
Corchorus trilocularis	Teliaceae
Portulaca oleracea	Portulacaceae
Sida acuta L.	Malvaceae
Tridax procumbens	Compositeae
Xanthium strumarium L.	Asteraceae
Sedges	
Cyperus rotundus	Cyperaceae
Cyperus esculentus	Cyperaceae

It was followed by T_8 diuron 80 % WP @ 1500 g *a.i.* ha^{-1}as PE *fb* pyrithiobac sodium 10 EC @ 125 g *a.i.* ha^{-1} as PoE @ 2-5 leaf stages of weeds *fb* IC @ 60 DAS (3.80 m^{-2}), (T_9) pendimethalin 30 EC @ 1250 g *a.i.* ha^{-1}as PE *fb* pyrithiobac sodium 10 EC @ 125 g *a.i.* ha^{-1} as PoE @ 2-5 leaf stages of weeds *fb* IC @ 60 DAS. At harvest the higher weed count (5.93 m^{-2}) was recorded in (T_1) metolachlor 50 % EC @ 800 g *a.i* ha^{-1} as PE *fb* IC @ 45 and 60 DAS after weedy check (6.14 m^{-2}) followed by T_5 diuron 80% WP @ 1500 g *a.i.* ha^{-1}as PRE *fb* IC @ 45 and 60 DAS (5.13 m^{-2}), T_6 pendimethalin 30 EC @ 1250 g *a.i.* ha^{-1}as PE *fb* IC @ 45 and 60 DAS (5.08 m^{-2}), (T_2) metolachlor 50 % EC @ 1000 g *a.i* ha^{-1} as PRE *fb* IC @ 45 and 60 DAS (5.02 m^{-2}), (T_3) metolachlor 50 % EC @ 1200 g *a.i* ha^{-1} as PE *fb* IC @ 45 and 60 DAS (4.88 m^{-2}), (T_4) metolachlor 50 % EC @ 2000 g *a.i* ha^{-1} as PE *fb* IC @ 45 and 60 DAS (4.69 m^{-2}) [8].

The chemical treatment had reported higher weed control than the cultural weed control alone at earlier stages. As the herbicides were systemic in their function, it disrupts the cell division and cell elongation in shoot and root meristem of susceptible plants [9]. At 45 DAS, Application of PE herbicides followed by PoE were significantly reduced the weed count compared to the sole application of pre-emergent chemicals. Pyrithiobac sodium, a newer type of acetolactase synthase inhibitor that affects the formation of amino acid in weeds, along with the aforementioned, tank

mixing of pyrithiobac and grassy herbicides may boost the phytotoxicity on weeds [10]. Further from 75 DAS to harvest, there was no significant effect of weeds on crop, as the cotton crop itself could smother the associated weeds due to its dense growth. Fully developed canopy reduced the availability of nutrients and water towards weeds. The results are in conformity with the findings of [11].

3.1.3 Dry weight of weeds

3.1.3.1 Dry weight of monocot weeds (g m^{-2})

The effect of herbicidal application on dry weight of *Bt* cotton is presented in Table 2. There was noted a significant variation in dry matter production with different weed management practices. During initial period at 15 and 30 DAS, the highest weed dry matter production (5.73 g m^{-2} and 12.76 g m^{-2}) were found in weedy check followed by metolachlor 50% EC @ 800g *a.i* ha^{-1}as PE *fb* IC @ 45 and 60 DAS (T_1) and the least was found in two hand weeding @ 15 and 30 DAS *fb* IC at 45, 60 and 75 DAS (T_{10}) followed by metolachlor 50 % EC @ 2000 g *a.i* ha^{-1} as PE *fb* IC @ 45 and 60 DAS (T_4) at 15 (4.06 g m^{-2}) and 30 DAS (8.46 g m^{-2}).

At 45 DAS, metolachlor 50 % EC @ 1000 g *a.i.* ha^{-1} as PE *fb* pyrithiobac sodium 10 EC @ 125 g *a.i.* ha^{-1} as PoE @ 2-5 leaf stages of weeds *fb* IC @ 60 DAS (T_7) recorded the lower weed dry matter production (3.83 g m^{-2}) followed by (T_8) diuron 80 % WP @ 1500 g *a.i.* ha^{-1}as PE *fb* pyrithiobac sodium 10 EC @ 125 g *a.i.* ha^{-1} as PoE @ 2-5 leaf stages of weeds *fb* IC @ 60 DAS (5.07 g m^{-2}), (T_9) pendimethalin 30 EC @ 1250 g *a.i.* ha^{-1}as PRE *fb* pyrithiobac sodium 10 EC @ 125 g *a.i.* ha^{-1} as PoE @ 2-5 leaf stages of weeds *fb* IC @ 60 DAS (5.00 g m^{-2}). The higher weed dry matter weight recorded in T_1 [metolachlor 50 % EC @ 800 g *a.i* ha^{-1} as PRE *fb* IC @ 45 and 60 DAS (11.71 g m^{-2})] was next to weedy check (13.47 g m^{-2}). Almost similar trend was observed at 75 DAS and harvest.

Vigour is just as crucial as quantity for determining weeds' competitive abilities. Weeds at lower densities can nevertheless harm crops just as much as those at higher densities. Therefore, weed dry matter per unit area is a better index than weed count to evaluate the impact of weeds on crops. Among herbicidal applications, at initial days from 15 DAS up to 45 DAS the treatments receiving PRE emergent applications reported lower weed dry matter weight [12] and later flush of weeds were controlled effectively by the application of PRE emergent followed by POST emergent herbicidal application [13].

3.1.3.2 Dry weight of dicot weeds (g m^{-2})

The application of metolachlor 50 % EC @ 2000 g *a.i* ha^{-1} as PRE *fb* IC @ 45 and 60 DAS (T_4) recorded lower weed dry weight at (3.94 g m^{-2}) 15 and 30 DAS (9.35 g m^{-2}) after weed free check (Two hand weeding @ 15 and 30 DAS *fb* IC at 45, 60 and 75 DAS).

There was a change in dry matter accumulation after 45 DAS and up to harvest which follows a same trend. The treatment T_7 recorded the lower weed dry weight (3.75 g m^{-2}) after weed free check followed by T_8 (4.81 g m^{-2}) and T_9 (3.77 g m^{-2}) at 45 DAS. The higher weed dry weight was observed in T_1 (11.71 g m^{-2}) after weedy check followed by (9.81 g m^{-2}) T_2 (Metolachlor 50% EC @ 1000g *a.i.* ha^{-1}as PRE *fb* IC @ 45 and 60 DAS).

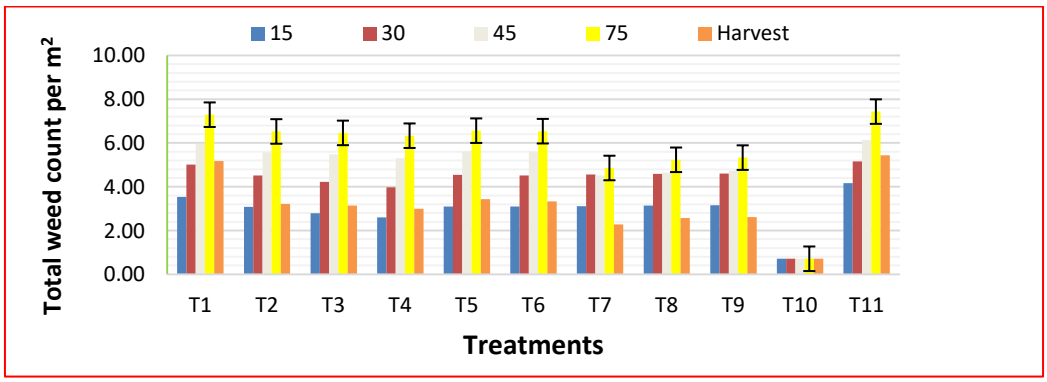

Fig. 1 Total weed count per m^2 in *Bt* cotton at different stages of crop growth as influenced by weed management treatments

Table 2. Effect of different herbicidal application on dry weight of monocot and dicot weed in *Bt* cotton, g m^{-2}

Treatments	Dry weight of monocot weeds					Dry weight of dicot weeds				
	15DAS	**30DAS**	**45DAS**	**75DAS**	**Atharvest**	***15DAS***	***30DAS***	***45DAS***	***75DAS***	***Atharvest***
T1 - Metolachlor 50 % EC @ 800g *a.i. h*ha^{-1}as PE *fb* IC @ 45 and 60 DAS	5.33	11.35	11.71	12.60	10.29	5.11	11.61	11.80	12.67	10.29
T2 - Metolachlor 50 % EC @ 1000 g *a.i.* ha^{-1}as PE *fb* IC @ 45 and 60 DAS	4.74	9.60	9.81	9.32	7.49	4.41	9.65	9.81	9.34	7.54
T3 - Metolachlor 50 % EC @ 1200 g *a.i*. ha^{-1}as PE *fb* IC @ 45 and 60 DAS	4.38	9.35	9.79	9.30	7.47	4.06	9.42	9.70	9.25	7.29
T4 - Metolachlor 50 % EC @2000 g *a.i*. ha^{-1}as PE *fb* IC @ 45 and 60 DAS	4.06	8.46	9.63	9.26	7.27	3.94	9.35	9.63	9.23	7.27
T5 - Diuron 80 % WP @ 1500 g *a.i* ha^{-1}as PE *fb* IC @ 45 and 60 DAS	4.77	9.62	9.77	9.39	7.42	4.48	9.67	9.74	9.46	7.40
T6 – Pendimethalin 30 EC @ 1250 g *a.i.*ha^{-1}as PE *fb* IC @ 45 and 60DAS	4.76	9.61	9.74	9.37	7.25	4.45	9.66	9.81	9.41	7.49
T7 – Metolachlor 50 % EC @ 1000 g *a.i.* ha^{-1}as PE *fb* Pyrithiobac sodium 10 EC @ 125 g *a.i.* ha^{-1} as PoE @ 2-5 leaf stages of weeds *fb* IC @ 60 DAS	4.78	9.63	3.83	4.81	3.77	4.50	9.68	3.75	4.80	3.77
T8 - Diuron 80 % WP @ 1500 g *a.i.* ha^{1}as PE *fb* Pyrithiobac sodium10 EC @ 125 g *a.i.* ha^{-1} as PoE @ 2-5 leaf stages of weeds *fb* IC @ 60 DAS	4.79	9.64	5.07	6.15	4.67	4.51	9.69	4.98	6.15	4.71
T9 - Pendimethalin 30 EC @ 1250 g *a.i.* ha^{-1}as PE *fb* Pyrithiobac sodium 10 EC @125 g *a.i.* ha^{-1}as PoE @ 2-5 leaf stages of weeds *fb* IC @ 60 DAS	4.80	9.65	5.00	6.12	4.78	4.52	9.70	4.81	6.04	4.81
T10 -Two hand weeding @ 15 and 30 DAS *fb* IC at 45, 60 and 75 DAS	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
T11 -Weedy check	5.73	12.76	13.47	14.92	12.13	5.70	12.84	13.73	15.06	12.05
S.Em±	0.17	0.33	0.34	0.31	0.24	0.20	0.32	0.31	0.30	0.26
CD at 5%	0.50	0.96	0.99	0.91	0.70	0.59	0.95	0.92	0.89	0.76

EC - Emulsifiable concentrate, WP – Wettable powder, IC – Intercultivation; PE - Pre-emergent, PoE – Post emergent, DAS- Days after sowing; Data subjected for transformation using $(x + 1)^{1/2}$*, Where x is weed coun*

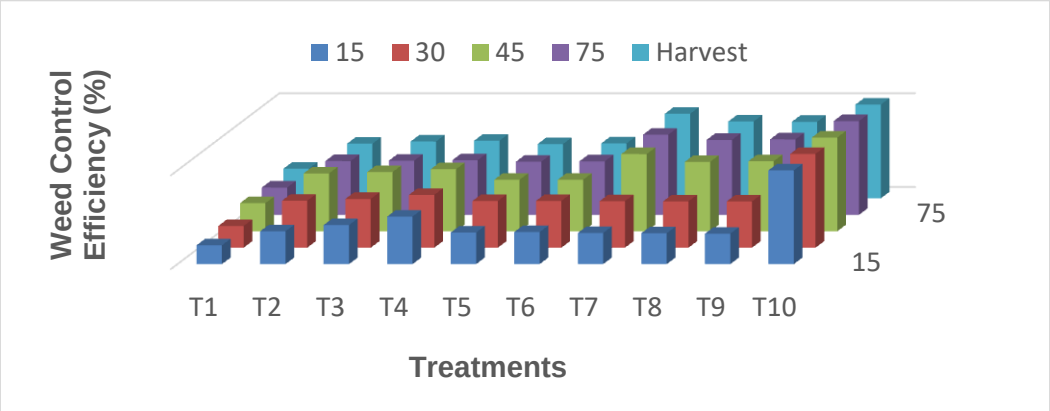

Fig. 2. Weed control efficiency in *Bt* cotton as influenced by different weed management practices

Among the Post emergent herbicidal applications, pyrithiobac sodium chemical was found as the most superior herbicide. Metolachlor provides an alternative mode of action for use on pre emerged weeds, creates flexibility for the post emergent application. Hence it controlled more weeds than other chemicals. These findings are in agreement with the report of [14,15,16].

3.1.4 Weed control efficiency (%)

The weed control efficiency depicted in the Fig. 2 showed a significant variation in its efficiency at different stages of growth with the different method of weed control treatments. At 15 DAS two hand weeding @ 15 and 30 DAS *fb* IC at 45, 60 and 75 DAS found the highest weed control efficiency (100 %) followed by metolachlor 50 % EC @ 2000 g *a.i* ha^{-1} (50.65 %), metolachlor 50 % EC@ 1200 g *a.i* ha^{-1} as PE *fb* IC @ 45 and 60 DAS (41.62 %), metolachlor 50 % EC @ 1000 g *a.i* ha^{-1} as PE *fb* IC @ 45 and 60 DAS (34.93 %). The least efficiency was noted in (T_1) metolachlor 50 % EC @ 800 g *a.i.* ha^{-1}as PE *fb* IC @ 45 and 60 DAS followed by (T_9) Pendimethalin 30 EC @ 1250 g *a.i.* ha^{-1}as PE *fb* Pyrithiobac sodium 10 EC @ 125 g *a.i.* ha^{-1} as PoE @ 2-5 leaf stages of weeds *fb* IC @ 60 DAS. Similar, trend was noticed at 30 DAS.

At 45 DAS (82.33 %), 75 DAS (85.46 %) and harvest (90.22 %) higher weed control efficiency was observed with the application of metolachlor 50 % EC @ 1000 g *a.i.* ha^{-1} as PE *fb* pyrithiobac sodium 10 EC @ 125 g *a.i.* ha^{-1} as PoE @ 2-5 leaf stages of weeds *fb* IC @ 60 DAS (T_7) followed by T_8 and T_9. The lower weed control efficiency was recorded with the application of metolachlor 50% EC @ 800g *a.i* ha^{-1}as PE *fb* IC @ 45 and 60 DAS (T_1) at 45 DAS (29.97 %), 75 DAS (29.07 %) and harvest (31.70 %).

The efficiency of weed control is inversely correlated with the amount of weed dry mattedr used in the experiment. Among all other chemical treatments during the early phase at 15 and 30 DAS, treatments receiving PE herbicides showed the highest weed control efficiency. These findings are consistent with those made by [17, 18,19].

The herbicides that applied in a sequential manner had considerable effect on weed. The weed control efficiency of such treatments was comparable with weed free check and these findings are consistent with those previously published by [20,21,22]. Metolachlor and pyrithiobac sodium were the two most effective treatments controls majority of weeds. This was attributed by the alternative mode of action and also the presence of grassy weeds which effectively suppress the bulk of weeds. These findings corroborate with those previously published by [9,23,24 and 25].

4. CONCLUSION

Weeds are the most dangerous pest that affects the yield and quality of *Bt* Cotton. Herbicides that are selective for *Bt* Cotton and broad spectrum was used mainly in the field. The lowest weed density or weed count of any of the treatments was achieved with the weed free check followed by the administration of pre-emergent herbicides up to 45 DAS. Then, to prevent the further growth, PoE herbicides followed by PE herbicides were used. Hence, sequential application of herbicides was proved to be the

most effective in controlling weeds rather than sole application. Continuous application of herbicides creates residual problems as well as weed shift in the cotton growing area, later it develops herbicide resistant weeds. To avoid such menace, it's important to thoroughly research the weed flora and its morphology. In the cotton growing tract of the TBP command region, an integrated application of both chemical and manual weed management, followed by intercultural activities, had reported the best weed control efficiency. Every location has a distinctive weed flora that may be preserved by being aware of the local best weed management techniques.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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