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Relative density of weeds and weed indices as influenced by weed control options in cotton

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ABSTRACT

Field experiments were conducted at Professor Jayashankar Telangana State Agricultural University, Rajendranagar during *Kharif* 2017 for the evaluation of efficacy different doses of diuron in both red and black soils. The treatment consisted of test herbicides such as, diuron 80% WP at 0.5 kg/ha, 0.75 kg/ha and 1.0 kg/ha along with registered formulation of pendimethalin 38.7% CS at 677 g/ha, intercropping with green manure crop, mechanical weeding thrice at 20, 40, 60 DAS and unweeded control. The experiment was laid out in a randomised block design replicated thrice. The weed flora of the experimental field in red soil was dominated by *Cynodon dactylon*, *Rottboellia exaltata*, *Parthenium hysterophorus*, *Trianthema portulacastrum* and *Commelina benghalensis*. While in case of black soil, predominant flora was *Cynodon dactylon*, *Cyperus rotundus*, *Parthenium hysterophorus*, *Euphorbia geniculata*, *Tridax procumbens*, *Cyanotis cristata*, *Digera arvensis* and *Celosia argentia*. The treatments, mechanical weeding thrice at 20, 40 and 60 DAS, polymulch treatments reduced the weed growth in both red and black soils. Among the herbicides, diuron at 1.0 kg/ha *fb* pyrithiobac-sodium + quizalofop-ethyl in red soil and both diuron at 1.0 kg/ha and 0.75 kg/ha along with sequential application of herbicides reduced the density of weeds. Diuron could reduce the broad-leaved weeds and grasses except itch grass. Sedges are also could not be reduced by diuron. The lower values of weed persistence index was obtained with herbicidal treatments *i.e.*, diuron at 1.0 and 0.75 kg/ha *fb* pyrithiobac-sodium + quizalofop-ethyl. The crop resistance index and treatment efficiency index were superior in case of polymulch and mechanical weeding thrice at 20, 40 and 60 DAS.

In textile industry cotton plays vital role in supplying raw materials to the tune of 85% of total requirement in India. It has immense potentiality to share foreign exchange of 38% of total export of Indian economy besides providing employment to 60 million people in India (Kairon and Venugopalan 2000). Cotton is grown in an area of 11.76 Mha, while the total production of cotton in India is 6.21 million bales (170 kg each) in 2015-16 against the production of 34.80 million bales in 2014-15. Yield level in this crop keeps fluctuating year after year depending upon the problem of insect pest and diseases that are closely associated with the climatic conditions in the region. Since, the crop has long growth cycle, it has to pass through frequent rains and thus weeds also pose a serious problem. Losses caused by weeds in cotton ranges from 50 to 85% depending upon the nature and intensity of weeds. The critical period of weed competition in cotton was found to be 15 to 60 days (Sharma 2008). Pre-emergence herbicides are available for controlling weeds, the need for post-emergence herbicide are often realised to combat the weeds emerged during crop growth. Alachlor and pendimethalin are the most widely used and registered herbicides for weed control in cotton. Continuous use of any herbicide may lead to the development of resistance in weeds therefore, there is need for alternative herbicides. Hence diuron which is selective to cotton and having a longer persistence in soil can be a better substitute. In a field experiment conducted in PJTSAU, phytotoxicity was observed at the dosage of 1 kg/ha. So evaluation of different doses of diuron for weed control is needed. The relative density of weeds is presented in this paper as influenced by different doses of diuron in rainfed cotton in both red and black soils.

A field experiment was conducted during *Kharif*, 2017 at College farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana State. The farm is geographically located at an altitude of 542.3 m above mean sea level at 17°19' N latitude and 78°23' E longitude in the Southern Telangana agro-climatic zone of Telangana. According to Troll's (Troll 1965) climatic classification, it falls under semi-arid tropics (SAT). The experiment was conducted in red and black soil and laid out in a randomised block design with three replications. The treatments included three doses of diuron (0.5, 0.75 and 1.0 kg/ha), pendimethalin 38.7% CS at 677 g/ha as PE followed by sequential application of pyrithiobac-sodium 10% EC 62.5 g/ha + quizalofop-p-ethyl 5% EC 50 g/ha, intercropping of cotton with green manure crop (sunhemp), mechanical weeding thrice at 20, 40 and 60 DAS (weed free), polymulch and unweeded control.

'*Mallika*' *Bt* was sown with a seed rate of 2.5 kg/ha. One-two seeds per hill were sown at a spacing of 75 x 75 cm to facilitate the use of power weeder in both directions in case of mechanical weeding. Pre-emergence herbicides were sprayed on the third day after sowing. Diuron 80% W.P. at 0.5 kg/ha, diuron 80% W.P. at 0.75 kg/ha, diuron 80% WP 1.0 kg/ha, pendimethalin 38.7% CS 677 g/ha were sprayed on the third day, pyrithiobac-sodium 10% EC 62.5 g/ha+ quizalofop-ethyl 5% EC 50 g/ha were sprayed at 2-3 leaf stage of the weeds. In the intercropping treatment the intercrop sunhemp was sown along with cotton. Polymulch was spread 8 DAS after emergence of the seedling. Mechanical weeding at 20, 40, 60 DAS was done with power weeder and an unweeded check was maintained.

The important weed species associated with *Bt* Cotton crop in the experimental area were recorded at 30, 60 and 90 DAS. Weed count was taken at 30, 60 and 90 DAS in two randomly selected quadrats (0.5 x 0.5 m) in each plot. At every sampling, individual species were separated and expressed as number/m. The sampling was done outside the net plot but within the gross plot. The treatment wise total weed count was recorded and expressed as no./m^2. The total weeds enclosed in the quadrat were carefully cut close to the ground level with the help of weeding hook. The relative weed density was calculated by following formula:

$$\text{Relative weed density} = \frac{\text{Density of individual species in the community}}{\text{Total density of weeds in the community}} \times 100$$

The observation on weeds at 60 days of sowing and dry weight of crop and grain yield at harvest have been presented in (**Table 1**). The various indices developed by Mishra and Misra (1997) have been used to identify the weed persistence, crop resistance and phytotoxic effect due to herbicidal treatments as mentioned below calculated on the basis of mean data of two years and have been presented in (**Table 2**) along with economics of cultivation.

Weed persistence index (WPI): (Dry weight of weeds in treated plot/dry weight of weeds in control plot) x (weed count in the control plot / weed count in the treated plot) (Mishra *et al*. 2016).

Crop resistance index (CRI): (dry matter production by crop in the treatment plot/dry matter production by crop in the control plot) x (dry matter production of weed in control plot/dry matter production of weeds in treatment plot) (Mishra *et al*. 2016).

Agronomic management index (AMI): (percentage increase in yield over control - percentage reduction of weeds)/percentage control of the pest (weed/insect).

Herbicide/ treatment efficiency index (TPI): [(yield of treatment- yield of control)*100/ yield of control)]/ (weed weight in treatment/ weed weight in control)

Weed flora

The weed flora was recorded on 30, 60 and 90 DAS during the crop growth period. The density of weed flora varied with the treatments adopted. In the red soil, among the grasses *Cynodon dactylon*, *Rottboellia exaltata*, *Dactyloctenium aegyptium* and *Dinebra retroflexa* were noticed. *Cyperus rotundus* was the only sedge present in the field. Among the broad-leaved weeds, *Parthenium hysterophorus*, *Euphorbia geniculata*, *Trianthema portulacastrum*, *Trichodesma indica*, *Commelina benghalensis*, *Digera arvensis*, *Tridax procumbens*, and *Phyllanthus niruri* were observed in the field.

In the black soil, among the grasses *Cynodon dactylon*, *Rottboellia exaltata* and *Echinocloa colona*, *Dactyloctenium aegyptium* were noticed. *Cyperus rotundus* was the only sedge present in the field. Among the broad-leaved weeds, *Parthenium hysterophorus*, *Euphorbia geniculata*, *Trianthema portulacastrum*, *Trichodesma indica*, *Cyanotis cristata*, *Digera arvensis* and *Celosia argentia* were observed in the field.

Relative weed density

The influences of different weed control practices adopted on the relative density of grasses, broad leaved weeds and sedges is studied. The relative density of grasses, BLW's and sedges as in case of red soil is depicted in **Table 1, 2** and **3** respectively. While that of grasses in **Table 4**, BLW's in **Table no. 5,6** and sedges in **Table 7** as in case of black soils.

In black soil: At 30 DAS, sedges were the dominant weed flora in diuron 1.0 kg/ha, 0.75 kg/ha as PE *fb* pyrithiobac-sodium + quizalofop-ethyl as PoE to the tune of 90% and the grasses were absent while the broad-leaved weeds were upto 10%. While in case of diuron 0.5 kg/ha and pendimethalin PE *fb* pyrithiobac sodium + quizalofop-ethyl as PoE, broad-leaved weeds and sedges were predominant. *Parthenium hysterophorus*, *D. arvensis* and *E. geniculata* were the dominant weeds among the broad-leaved weeds. *C. argentea* were the least dominant broad-leaved weed and *T. procumbens* was absent at 30 DAS. While the grasses were least dominant. Similar results were observed even at 60 DAS. But the relative density was increasing in all the treatments and also in diuron treatments as the number of days increased. At 90 DAS, in diuron 1.0 kg/ha, 0.75 kg/ha and 0.5 kg/ha as PE *fb* pyrithiobac-sodium + quizalofop-ethyl as PoE sedges were dominant and the broad-leaved weeds and grasses couldn't exceed 20%. In the rest of the treatments, broad-leaved weeds and sedges remained proportionately while among the broad-leaved weeds *P. hysterophorus* was the dominant while rest of the treatments remained less than 10% and *D. arvensis* was highest only in mechanical weeding thrice at 20, 40 and 60 DAS. However the grasses recorded the least relative density.

In red soil: At 30 DAS, diuron treatments PE *fb* pyrithiobac-sodium + quizalofop-ethyl as PoE recorded the higher relative density of sedges upto 80% and *R. exaltata* was also present. *R. exaltata*, *T. portulacastrum* and *C. bengalensis* were present proportionately in other treatments. *R. exaltata* was the dominating grass and weed in the red soil while among the broad-leaved weeds, *T. portulacastrum* was the dominant. *D. aegyptium* was absent at 30 and 60 DAS. Similar results were obtained at 60 DAS. All the three were found to be even at 90 DAS. In diuron treatments *C. rotundus* and *R. exaltata* were similar in relative density while in other treatments broad-leaved weeds were also prevalent. *T. portulacastrum* and *E. geniculata* were absent at 90 DAS as the life span of the weeds was completed. *P. hysterophorus* was the predominant broad-leaved weed.

It was observed that diuron could not control *C. rotundus* and *R. exaltata*. Broad-leaved weeds and other grasses except *R. exaltata* were effectively controlled. While pendimethalin could not control *P. hysterophorus*. However in both the soils, mechanical weeding thrice at 20, 40 and 60 DAS and polymulch effectively controlled the weeds. The season long reduced density of weeds in polythene mulch might be due to the sensitivity of the most of the weed seeds to light. So these weed seeds did not germinate under the plastic, which caused a reduction in population (Mahajan *et al.* 2007). Sequential application of herbicides along with application of PoE herbicides resulted in lower weed density which could be attributed to weed free situation during initial stages and further control of new flush of weeds by application of post-emergence herbicides at 25 DAS and thus, reducing the weed competition during critical initial to peak growth period of *Bt* cotton. Similar results were reported by Chetan *et al.* (2016), Prabhu *et al.* (2011), Nalini *et al.* (2013) and Hariharasudhan *et al.* (2017).

Weed indices

Weed indices like weed persistence index, crop resistance index and herbicide/treatment efficiency are calculated as to know the tolerance of weeds against weed control options adopted, resistance offered by the crop against the weeds and individual treatment efficiency. The data required for the calculation of these indices such as crop dry matter production, weed count, weed dry matter production and yield of both the soils are depicted in **Table 8**.

Table 1. Relative density of grasses as influenced by weed management measures adopted in red soils

Treatment	*Cynodon dactylon*			*Rottoboelia exaltata*			*Dactyloctenium aegyptium*			Total grasses		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Diuron 0.5 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	1.67	1.32	0	7.67	45.44	37.03	0	0	3.50	9.33	46.75	40.53
Diuron 0.75 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	0.98	0.47	0	13.30	42.70	55.32	0	0	0.98	14.28	43.17	56.30
Diuron 1.0 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	1.39	0	0	13.61	34.66	49.93	0	0	0.00	15.00	34.66	49.93
Pendimethalin at 677 g/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	0.56	2.11	1.19	8.05	51.44	41.21	0	0	5.33	8.62	53.54	47.73
Cotton + sunhemp	3.26	1.55	6.01	31.36	40.03	26.68	0	0	3.39	34.62	41.58	36.07
Mechanical weeding at 20, 40, 60 DAS	24.17	4.44	16.25	18.59	31.60	25.00	0	0	6.67	42.76	36.04	47.92
Control (unweeded)	3.15	0.39	4.99	11.98	43.04	33.59	0	0	4.34	15.13	43.43	42.91
Polymulch of 0.25 mm thickness	4.17	1.67	13.35	9.88	52.58	21.79	0	0	4.17	14.05	54.24	39.30

Weed persistence index (WPI)

The weed persistence data indicates the relative dry matter accumulation of weeds per count in comparison to control. Weed data at 60 DAS is considered for the calculation of the WPI. The WPI varied with the treatments and also the soil type and data is depicted in **Table 8**.

In red soil: The highest WPI was observed in case of intercropping with sunhemp (1.34) indicating resistance of escaped weeds to control measures while the rest of the treatments had values below. The lowest WPI values were observed with diuron 0.75 kg/ha (0.56), 1.0 kg/ha (0.59) PE *fb* pyrithiobac sodium + quizalofop-ethyl as PoE and mechanical weeding thrice at 20, 40 and 60 DAS (0.58) which indicates the lower persistence of escaped weeds indicating broad spectrum effect in controlling the weeds.

In black soil: Polymulch (4.06) recorded the highest WPI which indicates the resistance of escaped weeds to control measures which was followed by mechanical weeding thrice at 20, 40 and 60 DAS (1.82), intercropping with sunhemp (1.31), diuron 0.5 kg/ha *fb* pyrithiobac sodium + quizalofop-ethyl as PoE (1.23) and pendimethalin PE *fb* pyrithiobac sodium + quizalofop-ethyl as PoE (1.16). Diuron 0.75 kg/ha (0.86), 1.0 kg/ha (0.93) PE *fb* pyrithiobac sodium + quizalofop-ethyl as PoE registered lower WPI values having a broad spectrum control weeds.

Crop resistance index (CRI)

CRI indicates the increased vigour of crop plant due to weed control measures presented in **Table 8**. For the calculation of the CRI the values of crop dry matter production and weed dry matter production at 60 DAS is taken.

In red soil: The highest CRI was recorded by mechanical weeding thrice at 20, 40 and 60 DAS (30.03) which was followed by polymulch (27.04) and diuron 1.0 kg/ha PE *fb* pyrithiobac sodium + quizalofop-ethyl as PoE (11.65) indicating much less harmful effect of herbicides on crop as compared to other treatments. The lowest CRI was registered by intercropping with sunhemp (3.25).

In black soil: Similar to red soil, mechanical weeding thrice at 20, 40 and 60 DAS (5.99) registered higher CRI followed by polymulch (5.57), diuron 1.0 kg/ha (4.52) and 0.75 kg/ha (4.11) PE *fb* pyrithiobac sodium + quizalofop-ethyl as PoE.

Herbicide/treatment efficiency index (TEI)

TEI indicates the yield advantage by adoption of the treatment over the control in relation to the reduction in weed dry matter over control. The data is presented in **Table 8**.

Table 2. Weed density of BLW's as influenced by weed management measures adopted in red soils

Treatment	*Parthenium hysterophorus*			*Trianthema portulacastrum*			*Commelina benghalensis*			Total BLW's		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Diuron 0.5 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	6.00	5.52	5.87	25.83	9.18	0	0.83	4.09	0	32.67	18.79	5.87
Diuron 0.75 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	2.21	1.21	2.75	4.18	0.61	0	0	0	0	6.40	1.82	2.75
Diuron 1.0 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	4.17	0	1.52	0	0	0	0	0	0	4.17	0.00	1.52
Pendimethalin at 677 g/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	12.58	7.98	10.89	8.12	4.11	0	7.98	5.75	0	28.69	17.84	10.89
Cotton + sunhemp	7.13	8.07	6.99	28.55	8.63	0	5.42	6.49	0	41.10	23.18	6.99
Mechanical weeding at 20, 40, 60 DAS	15.06	5.25	25.42	9.23	5.44	0	6.67	4.99	0	30.96	15.68	25.42
Control (unweeded)	12.26	10.01	6.58	33.18	3.04	0	4.19	8.43	0	49.62	21.48	6.58
Polymulch of 0.25 mm thickness	13.69	9.70	24.17	13.33	1.67	0	10.83	0	0	37.86	11.36	24.17

Table 3. Weed density of sedges as influenced by weed management measures adopted in red soils

Treatment	*Cyperus rotundus*		
	30 DAS	60 DAS	90 DAS
Diuron 0.5 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	56.33	33.31	54.52
Diuron 0.75 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	79.32	55.02	40.60
Diuron 1.0 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	80.83	65.34	48.56
Pendimethalin at 677 g/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	62.13	24.83	40.93
Cotton + sunhemp	18.45	30.05	56.14
Mechanical weeding at 20, 40, 60 DAS	26.28	46.76	26.67
Control (unweeded)	29.36	29.78	50.24
Polymulch of 0.25 mm thickness	29.29	31.06	35.14

Table 4. Relative density of grasses as influenced by weed management measures adopted in black soils

Treatment	*Cynodon dactylon*		
	30 DAS	60 DAS	90 DAS
Diuron 0.5 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	0.81	2.08	3.36
Diuron 0.75 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	0.00	2.17	2.19
Diuron 1.0 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	0.00	1.23	2.95
Pendimethalin at 677 g/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	1.01	0.00	5.94
Cotton + sunhemp	2.34	6.00	6.33
Mechanical weeding at 20, 40, 60 DAS	0.00	2.38	6.73
Control (unweeded)	2.60	2.23	4.15
Polymulch of 0.25 mm thickness	2.67	11.64	12.29

Table 5. Relative density of BLW's as influenced by weed management measures adopted in black soils

Treatment	*Parthenium hysterophorus*			*Celosia argentia*			*Digera arvensis*			Total BLW's		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Diuron 0.5 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	38.36	26.88	8.21	6.35	1.53	1.15	0.00	5.83	3.70	48.01	39.47	14.96
Diuron 0.75 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	6.67	8.87	7.75	0.00	0.58	0.00	0.00	0.72	3.45	8.76	13.46	11.10
Diuron 1.0 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	9.88	3.61	5.60	0.00	0.00	0.00	0.00	0.48	1.28	7.85	4.33	7.52
Pendimethalin at 677 g/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	44.88	41.24	33.18	1.61	1.11	3.67	6.84	12.14	6.67	60.34	59.02	45.61
Cotton + sunhemp	15.35	23.63	19.09	4.87	3.57	4.23	35.98	30.93	8.83	62.50	66.29	41.03
Mechanical weeding at 20, 40, 60 DAS	14.37	37.43	22.22	0.00	0.00	0.00	32.61	20.50	10.44	61.11	79.70	34.45
Control (unweeded)	34.62	27.52	31.31	2.08	0.72	1.76	29.45	8.20	6.10	77.19	50.17	46.67
Polymulch of 0.25 mm thickness	22.36	36.01	37.79	2.22	2.22	6.48	3.90	10.56	5.81	39.62	64.68	62.53

Table 6. Relative density of BLW's as influenced by weed management measures adopted in black soils

Treatment	*Euphorbia geniculata*			*Cyanotis cristata*			*Tridax procumbens*		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Diuron 0.5 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	4.21	2.04	0	1.06	0.00	1.04	0	3.15	3.13
Diuron 0.75 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	0.83	3.15	0	0.00	0.00	4.37	0	0.00	0.00
Diuron 1.0 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	0.00	0.00	0	0.00	0.00	1.04	0	0.00	1.28
Pendimethalin at 677 g/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	0.80	1.67	0	6.33	1.43	0.00	0	1.11	4.94
Cotton + sunhemp	1.93	0.00	0	4.49	7.83	2.17	0	0.00	4.48
Mechanical weeding at 20, 40, 60 DAS	9.29	2.08	0	0.00	24.34	6.73	0	7.41	3.70
Control (unweeded)	5.54	1.27	0	5.34	8.45	3.02	0	3.44	6.03
Polymulch of 0.25 mm thickness	7.45	14.34	0	4.44	0.00	0.00	0	0.00	5.81

Table 7. Effect of weed control measures on crop dry matter, weed count, weed dry matter and yield

Treatment	Crop dry matter at 60 DAS (g/plant)		Weed dry matter at 60 DAS (g/m^2)		Weed count at 60 DAS (no./m^2)		Kapas yield (t/ha)	
	Red soil	Black soil	Red soil	Black soil	Red soil	Black soil	Red soil	Black soil
Diuron 0.5 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	91.33	63.67	31.50	33.57	63.67	63.33	1.41	1.55
Diuron 0.75 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	96.33	90.00	25.50	23.02	62.00	61.67	1.62	2.65
Diuron 1.0 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	109.33	90.33	17.70	20.99	41.33	52.00	2.05	2.04
Pendimethalin at 677 g/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	91.08	76.67	32.90	34.50	59.33	61.00	1.39	1.50
Cotton + sunhemp	67.00	61.67	38.90	29.37	39.67	58.33	0.65	1.03
Mechanical weeding at 20, 40, 60 DAS	121.00	103.00	7.60	18.08	18.00	23.00	2.11	2.75
Control (unweeded)	29.00	41.00	54.70	43.08	75.00	99.67	0.1	0.10
Polymulch of 0.25 mm thickness	119.00	105.00	8.30	19.86	17.00	11.33	2.42	3.46

In red soil: The highest TEI was recorded by polymulch (18596) which was followed by mechanical weeding thrice at 20, 40 and 60 DAS (17560) and diuron 1.0 kg/ha PE *fb* pyrithiobac sodium + quizalofop-ethyl as PoE (7309) indicating the higher yield advantage in relation to the reduction in weed dry matter. The lowest CRI was registered by intercropping with sunhemp.

In black soil: Polymulch (7150) registered higher TEI followed by mechanical weeding thrice at 20, 40 and 60 DAS (6183) and diuron 0.75 kg/ha PE *fb* pyrithiobac sodium + quizalofop-ethyl as PoE (4684).

Table 8. Effect of weed control measures on weed indices in cotton

Treatment	Weed persistence index		Crop resistance index		Treatment efficiency index	
	Red soil	Black soil	Red soil	Black soil	Red soil	Black soil
Diuron 0.5 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	0.68	1.23	5.47	1.99	2774	1824
Diuron 0.75 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	0.56	0.86	7.13	4.11	3977	4684
Diuron 1.0 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	0.59	0.93	11.65	4.52	7309	3900
Pendimethalin at 677 g/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	0.76	1.31	5.22	2.34	2616	1709
Cotton + sunhemp	1.34	1.16	3.25	2.21	957	1337
Mechanical weeding at 20, 40, 60 DAS	0.58	1.82	30.03	5.99	17560	6183
Control (unweeded)	0.67	4.06	27.04	5.56	18596	7150

Table 9. Relative density of sedges as influenced by weed management measures adopted in black soils

Treatment	*Cyperus rotundus*		
	30 DAS	60 DAS	90 DAS
Diuron 0.5 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	48.68	58.50	77.33
Diuron 0.75 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	92.50	84.49	82.25
Diuron 1.0 kg/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	90.12	94.67	87.85
Pendimethalin at 677 g/ha *fb* pyrithiobac-sodium 62.5 g/ha + quizalofop-ethyl 50 g/ha	38.52	40.85	45.61
Cotton + sunhemp	31.35	27.63	54.86
Mechanical weeding at 20, 40, 60 DAS	42.28	12.80	61.28
Control (unweeded)	18.26	44.24	47.64
Polymulch of 0.25 mm thickness	61.40	52.93	54.80

The higher yield was obtained in diuron at 0.75 kg/ha but not in 1 kg/ha due to the reduction in plant population by the phytotoxic effect on the crop at higher dose.

In both the soil polymulch obtained higher TPI due to the increased yield with increased moisture and nutrient supply in polymulch treatment (Loy *et al.* 1998) even though the mechanical weeding had higher weed control efficiency.

The relative weed density was minimum in mechanical weeding thrice at 20, 40 and 60 DAS and polymulching at all the stages of crop growth and among the herbicides, diuron at 1.0 kg/ha *fb* pyrithiobac sodium + quizalofop-ethyl reduced the weed density in red soil. In case of black soil in mechanical weeding thrice at 20, 40 and 60 DAS and polymulching significantly reduced the weed density and among the chemical treatments diuron at 1.0 kg/ha and 0.75 kg/ha along with sequential application of herbicides reduced the weed density. The lower values of weed persistence index was herbicidal treatments *i.e.*, diuron at 1.0 and 0.75 kg/ha *fb* pyrithiobac-sodium + quizalofop-ethyl. The crop resistance index and treatment efficiency index were superior in case of polymulch and mechanical weeding thrice at 20, 40 and 60 DAS.

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