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## Evaluation of herbicide mixtures on weed control in cotton under weed detection techniques

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### Abstract

A field experiment was conducted at Agricultural college and Research Institute, Madurai during, 2019-20 to evaluate the bio-efficacy of herbicide mixtures on weed and productivity of cotton. Statistical design used in the experiment is Split plot and replicated thrice. Treatments tested were, three weed detection techniques as main plot and the different herbicide mixtures were allotted to sub plots. The herbicide mixtures were quantified and applied based on the weed spread area. Comparing all the herbicide mixtures, the experimental investigation concludes that application of 75% dosage of Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> at 15 DAS as early post emergence herbicide followed by Post emergence application of Fluazifop at 140 g a.i ha<sup>-1</sup> + Fenoxoprop at 40 g a.i. ha<sup>-1</sup> at 40 DAS, saved the quantity of herbicide, also exhibits higher bio efficacy with the detection of weeds through drone camera (M<sub>3</sub>).

**Keywords:** Herbicide mixture, efficiency, weed detection technique, weed indices

### 1. Introduction

Cotton is presently the most important plant fibre crop in the world, with a total covering of 34.5 million hectares farmed commercially in temperate and tropical regions of more than 50 nations. Cotton area in India is 13.47 million ha in 2019-20, with an output of 360.6 lakh bales and a productivity of 455 kg lint ha<sup>-1</sup>. Cotton is the most significant traditional fibre crop in Tamil Nadu, with an area of 0.17 million ha, an output of 0.04 million tonnes (M t), and a productivity of 418 kg lint ha<sup>-1</sup>. Weeds thrive in cotton fields due to their initial sluggish growth and adoption of wider spacing (Javaid and Anjum, 2006) [2]. Weeds in cotton deplete 30-50% of applied fertiliser, 20-40% of moisture, and diminish seed cotton output by 13-41% (Jayakumar *et al.*, 2008) [3]. Knowledge on the kind of weeds, their growth stage, and the density of present weeds infesting a cotton field is essential for determining the most effective herbicide mixture and dose (Iqbal and Cheema, 2008) [1]. All of this information should be gathered by mapping weeds individually in the field using various weed identification techniques. Furthermore, information on the efficiency of various herbicide mixes on cotton weeds has to be clarified.

Keeping all the above facts in view, an attempt was made to find out the efficacy and selectivity of different herbicides mixtures against complex weed flora to improve the productivity of cotton.

### 2. Materials and Methods

An experiment was conducted during 2019-20 in the garden land farms of the Agricultural college and Research institute, Madurai to study the bio-efficacy of herbicide mixtures on weed and productivity of cotton. The experiment was laid out in a Split plot Design with three replication. It consist of Three weed detection techniques as main factor *viz.*, M<sub>1</sub> - Manual method, M<sub>2</sub> - Image detection with manually operated camera and M<sub>3</sub> - Image detection with drone camera and eight mixtures of altered herbicide doses as weed management practices *viz.*, S<sub>1</sub> - 100% dosage of EPoE Propaquizafop @ 100 g a.i. ha<sup>-1</sup> on 15 DAS followed by POE Fenoxaprop ethyl @ 67.5 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 1, S<sub>2</sub> - 75% dosage of EPoE Propaquizafop @ 100 g a.i. ha<sup>-1</sup> on 15 DAS followed by POE Fenoxaprop ethyl @ 67.5 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 2, S<sub>3</sub> - 50% dosage of EPoE Propaquizafop @ 100 g a.i. ha<sup>-1</sup> on 15 DAS followed by POE Fenoxaprop ethyl @ 67.5 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 3, S<sub>4</sub> - 100% dosage of EPoE Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac

Sodium @ 62.5 g a.i ha<sup>-1</sup> on 15 DAS followed by POE Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 1, S<sub>5</sub> - 75% dosage of EPoE Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> on 15 DAS followed by POE Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 2, S<sub>6</sub> - 50% dosage of EPoE Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> on 15 DAS followed by POE Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 3, S<sub>7</sub> - Recommended practice (PE Pendimethalin @ 1 kg a.i. ha<sup>-1</sup> on 3 DAS + 1 HW on 40 DAS), S<sub>8</sub> - Unweeded control.

Cotton test variety used was SVPR-6. The recommended seed rate of 15 kg ha<sup>-1</sup>. The fuzzy seeds were treated with cow dung slurry and then with biofertilizers. Sowing was done on the ridges with 75 cm row spacing and 30 cm intra row spacing. The weed rating was done at few days after the sowing by observing the weed density, manually. Weed detection with manually operated camera is done with Canon 1200D camera and drone images were taken with DJI Phantom 4 pro. The weed area was determined with MATLAB software. The crop was irrigated as and when required. Herbicides were selectively applied on weeds with the help of Rope wick applicator.

Data on density and dry matter of weeds were recorded at 60 DAS with the help of 0.25 m<sup>2</sup> quadrat selected randomly in each plot. After identifying, the weed species were grouped into grasses, broad leaved weeds and sedges separately. Weed density was calculated on the basis of the total number of an individual weed species m<sup>-2</sup>. On the basis of weed data, different weed indices were computed using the standard procedure as following details:

### 2.1 Weed control efficiency (WCE)

Weed control efficiency was computed by adopting the following formula given by Mani *et al.* (1973) as follows:

$$\text{WCE (\%)} = \frac{\text{WPC} - \text{WPT}}{\text{WPC}} \times 100$$

Where, WPC is the weed dry weight in unweeded control (no. of plants per quadrat) and WPT is the weed dry weight in treated plot (no. of plants per quadrat).

### 2.2 Herbicide efficiency index (HEI)

This index represents the potential of a particular herbicide for controlling the weeds along with their phyto-toxicity effect on the crop (Krishnamurthy *et al.* 1975)<sup>[4]</sup>.

$$\text{HEI (\%)} = \frac{\text{Yt} - \text{Yc} \times 100}{\text{Yt} \times 100} \times 100$$

Where, Yt- crop yield from treated plot, Yc - crop yield from weedy check plot, WDMt - weed dry matter in treated plot and WDMc - weed dry matter in weedy check plot.

The economics of different treatments were worked out to evaluate the benefit accrued from the treatments applied in terms of net return (kg ha<sup>-1</sup>) and benefit-cost ratio as follows:

$$\text{Benefit Cost} = \frac{\text{Gross returns (Rs. ha}^{-1}\text{)}}{\text{Total cost [(cost of cultivation + treatment (Rs. ha}^{-1}\text{))]}$$

Data generated from the field experiments were subjected to the statistical analysis after square root transformation (x + 0.5) of the original data as appropriate for weed density and dry weight.

## 3. Results and Discussion

### 3.1 Weed flora

The experimental field was vastly invaded with mixed flora of weeds consisting of grass, broad leaved weed and sedges. Major flora found under the grasses include, *Echinochloa colona*, *Dactyloctenium aegyptium*, *Chloris barbata*. *Cleome viscosa*, *Phyllanthus niruri*, *Trianthema portulacastrum*, *Corchorus olitorius*, *Tridax procumbens* were found under broad leaved weeds and regarding sedges, *Cyperus rotundus* and *Fimbristylis miliacea* were observed.

### 3.2 Effect on weed density

At 60 DAS, the minimum weed density in grasses, broad leaved weeds and sedges were recorded in image detection with drone camera (M<sub>3</sub>) (11.54 m<sup>-2</sup>, 50.35 m<sup>-2</sup> and 9.03 m<sup>-2</sup> of grasses, broad leaved weeds and sedges respectively). This may be due to higher resolution, achieved from the data of drone camera corresponding to the target area which results in wide and precise coverage. However this technique was at par with the image detection technique with manually operated camera (M<sub>2</sub>) (12.42 m<sup>-2</sup>, 53.7 m<sup>-2</sup> and 9.65 m<sup>-2</sup> of grasses, broad leaved weeds and sedges respectively) (Table 1).

When comes to the herbicide mixtures, application of 75% dosage of Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> as early post emergence herbicide on 15 DAS followed by Post emergence application of Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 2 (S<sub>5</sub>) has lowest weed density (6.84 m<sup>-2</sup>, 34.76 m<sup>-2</sup> and 5.95 m<sup>-2</sup> of grasses, broad leaved weeds and sedges respectively) which was found significantly lower than the rest of the weed control options. It was followed by the application of pre emergence application of Pendimethalin @ 1 kg a.i. ha<sup>-1</sup> on 3 DAS + 1 hand weeding on 40 DAS (S<sub>7</sub>) (7.72 m<sup>-2</sup>, 40.18 m<sup>-2</sup> and 6.74 m<sup>-2</sup> of grasses, broad leaved weeds and sedges respectively) which is on par with application of 100% dosage of EPoE Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> on 15 DAS followed by POE Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 1 (S<sub>4</sub>) (8.41 m<sup>-2</sup>, 43.17 m<sup>-2</sup> and 7.02 m<sup>-2</sup> of grasses, broad leaved weeds and sedges respectively).

Regarding the interaction effect, detection of weeds through drone camera and the application of 75% dosage of Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> as early post emergence herbicide on 15 DAS followed by Post emergence application of Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 2 (M<sub>3</sub>S<sub>5</sub>) recorded the minimum weed density (3.63 m<sup>-2</sup>, 19.39 m<sup>-2</sup> and 3.37 m<sup>-2</sup> of grasses, broad leaved weeds and sedges respectively) at 60 DAS.

### 3.3 Effect on weed dry matter

The least dry matter production of grasses, broad leaved weeds and sedges were recorded in image detection with drone camera (M<sub>3</sub>) (73.71 kg ha<sup>-1</sup>, 133.08 kg ha<sup>-1</sup> and 18.01 kg ha<sup>-1</sup> of grasses, broad leaved weeds and sedges respectively) at 60 DAS. This treatment was at par with the image detection technique with manually operated camera (M<sub>2</sub>) (78.83 kg ha<sup>-1</sup>, 140.83 kg ha<sup>-1</sup> and 19.22 kg ha<sup>-1</sup> of grasses, broad leaved

weeds and sedges respectively) (Table 2).

Application of 75% dosage of Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> as early post emergence herbicide on 15 DAS followed by Post emergence application of Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 2 (S<sub>5</sub>) had least weed dry matter production (26.41 kg ha<sup>-1</sup>, 94.76 kg ha<sup>-1</sup> and 9.16 kg ha<sup>-1</sup> of grasses, broad leaved weeds and sedges respectively). This might be due to the effective performance of herbicides at particular dosage on entire foliage, which prevents the formation of new growth of the shoots. Also it seems that, antagonistic effect of herbicide mixture have been nullified due to the reduced concentration. It was followed by the pre emergence application of Pendimethalin @ 1 kg a.i. ha<sup>-1</sup> on 3 DAS + 1 hand weeding on 40 DAS (S<sub>7</sub>) which is on par with application of 100% dosage of EPoE Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> on 15 DAS followed by POE Fluazifop @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop @ 40 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 1 (S<sub>4</sub>). The highest weed dry matter was found with the unweeded control (S<sub>8</sub>) (353.36 kg ha<sup>-1</sup>, 341.25 kg ha<sup>-1</sup> and 58.81 kg ha<sup>-1</sup> of grasses, broad leaved weeds and sedges respectively).

Effect of interaction treatments shows that, detection of weeds through drone camera and the application of 75% dosage of Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> as early post emergence herbicide on 15 DAS followed by Post emergence application of Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 2 (M<sub>3</sub>S<sub>5</sub>) recorded the least dry matter of weeds (8.91 kg ha<sup>-1</sup>, 49.89 kg ha<sup>-1</sup> and 4.3 kg ha<sup>-1</sup> of grasses, broad leaved weeds and sedges respectively) at 60 DAS.

### 3.4 Effect on weed indices

Amongst herbicides, the maximum value of WCE (83.3%) and HEI (14.82%) was achieved by 75% dosage of Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> as early post emergence herbicide on 15 DAS followed by Post emergence application of Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 2 (S<sub>5</sub>). The sole application of single herbicide registered less WCE. Apart from control plot, application of 50% dosage of EPoE Propaquizafop @ 100 g a.i. ha<sup>-1</sup> on 15 DAS followed by POE Fenoxaprop @ 67.5 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 3(S<sub>3</sub>) have recorded least weed indices value [WCE (70.1%) and HEI (3.69%)] which indicates the resistance of escaped weeds to control measures (Table. 3). These results indicate that tank mix application of different herbicides gave better results in comparison to their solitary application. The combined

application of tank mix results in broad spectrum weed kill due to increased efficacy (Chhokar *et al.* 2011) [6].

Regarding the weed detection techniques, image detection with drone camera secured the highest weed indices value [WCE (71.2%) and HEI (8.28%)].

In the interaction effect, detection of weeds through drone camera and the application of 75% dosage of Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> as early post emergence herbicide on 15 DAS followed by Post emergence application of Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 2 (M<sub>3</sub>S<sub>5</sub>) recorded highest WCE (91.9%) and HEI (26.76%).

### 3.5 Effect on yield, net returns and BC ratio

Analysis of yield data exhibited that interaction of weed detection through drone camera and the application of 75% dosage of Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> as early post emergence herbicide on 15 DAS followed by Post emergence application of Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 2 (M<sub>3</sub>S<sub>5</sub>) reported highest seed cotton yield of 1752 kg ha<sup>-1</sup>. Also the same treatment acquired highest net returns of Rs. 52384 ha<sup>-1</sup> with the Benefit Cost ratio of 2.1 and it was followed by the same chemical treatment combined with the weed detection through manually operated camera (M<sub>3</sub>S<sub>5</sub>) (Rs. 45267 ha<sup>-1</sup> and 2.02 (Table 4)

Comparing to all other chemical combinations, application of 75% dosage of Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> as early post emergence herbicide on 15 DAS followed by Post emergence application of Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl 40 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating 2, secured an average percentage increase in yield (10-22.5%), Net return (24 – 47%) and BC ratio (11 – 21%).

This might be related to suppression of the enzyme acetolactate synthase (ALS), which functions as a catalyst in the first step of crucial amino acid production (valine, leucine and isoleucine). Better expression of yield attributes due to reduced weed infestation through these treatments may have assisted crop plants in accumulating more dry matter through increased nutrient uptake, which may have provided a greater quantity of photosynthates to developing sink in crop plants, producing more yield. (Walia *et al.* 2010) [7]. The results clearly concludes that the treatment possessing higher economic feasibility was directly linked with the higher production potential over unweeded control. (Charles *et al.* 2015) [8].

**Table 1:** Effect of herbicide mixtures under weed detection techniques on density of weed flora (no. m<sup>-2</sup>) at 60 DAS in cotton during 2019-20

Treatment	Grass				Broad leaved weed				Sedge			
	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean
S <sub>1</sub>	3.73 (13.44)	3.11 (9.21)	3.08 (9)	3.31 (10.55)	8.15 (65.93)	6.79 (45.66)	6.72 (44.73)	7.22 (52.1)	3.42 (11.21)	2.91 (7.97)	2.85 (7.64)	3.06 (8.94)
S <sub>2</sub>	3.81 (14.08)	3.16 (9.5)	3.11 (9.18)	3.36 (10.92)	8.32 (68.88)	6.89 (47.1)	6.78 (45.55)	7.33 (53.84)	3.49 (11.69)	2.91 (7.97)	2.86 (7.73)	3.09 (9.13)
S <sub>3</sub>	4.05 (15.93)	3.29 (10.38)	3.26 (10.14)	3.53 (12.15)	8.85 (77.84)	7.19 (51.25)	7.1 (49.99)	7.71 (59.69)	3.7 (13.23)	3.02 (8.64)	2.99 (8.47)	3.24 (10.11)
S <sub>4</sub>	3.01 (8.6)	2.98 (8.4)	2.95 (8.22)	2.98 (8.41)	6.67 (44.06)	6.58 (42.9)	6.56 (42.56)	6.6 (43.17)	2.79 (7.28)	2.73 (6.98)	2.7 (6.79)	2.74 (7.02)
S <sub>5</sub>	3.44 (11.4)	2.45 (5.5)	2.03 (3.63)	2.64 (6.84)	7.53 (56.2)	5.4 (28.68)	4.45 (19.39)	5.79 (34.76)	3.16 (9.53)	2.34 (4.97)	1.96 (3.37)	2.49 (5.95)
S <sub>6</sub>	4	3.26	3.19	3.48	8.72 (75.66)	7.11 (50.06)	6.95 (47.84)	7.59 (57.85)	3.65	2.99	2.93	3.19

	(15.53)	(10.15)	(9.67)	(11.78)					(12.85)	(8.47)	(8.09)	(9.81)
S <sub>7</sub>	3.06 (8.87)	2.57 (6.11)	2.94 (8.19)	2.86 (7.72)	6.72 (44.74)	5.92 (34.55)	6.46 (41.26)	6.37 (40.18)	2.89 (7.87)	2.44 (5.47)	2.72 (6.89)	2.68 (6.74)
S <sub>8</sub>	6.39 (40.35)	6.2 (38.05)	6.07 (36.36)	6.22 (38.25)	11.14 (123.62)	11.09 (122.66)	10.89 (118.23)	11.04 (121.51)	5.13 (25.85)	5.08 (25.32)	5.02 (24.72)	5.07 (25.3)
Mean	3.94 (16.02)	3.42 (12.42)	3.28 (11.54)		8.26 (69.62)	7.19 (53.7)	6.92 (50.35)		3.53 (12.44)	3.09 (9.65)	2.97 (9.03)	
	M	S	M x S	S x M	M	S	M x S	S x M	M	S	M x S	S x M
SEd	0.09	0.09	0.17	0.16	0.11	0.26	0.44	0.46	0.06	0.09	0.16	0.15
CD (p=0.05)	0.26	0.18	0.39	0.32	0.31	0.53	0.92	0.93	0.18	0.18	0.34	0.31

M<sub>1</sub> –Manual method; M<sub>2</sub> –Image detection with manually operated camera; M<sub>3</sub> – Image detection with drone camera; S<sub>1</sub>– 100% dosage of EPoE Propaquizafop @ 100 g a.i. ha<sup>-1</sup> at 15 DAS *fb* POE Fenoxaprop ethyl @ 67.5 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 1; S<sub>2</sub>– 75% dosage of EPoE Propaquizafop @ 100 g a.i. ha<sup>-1</sup> at 15 DAS *fb* POE Fenoxaprop ethyl @ 67.5 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 2; S<sub>3</sub>– 50% dosage of EPoE Propaquizafop @ 100 g a.i. ha<sup>-1</sup> at 15 DAS *fb* POE Fenoxaprop ethyl @ 67.5 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 3; S<sub>4</sub>– 100% dosage of EPoE Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> at 15 DAS *fb* POE Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 1; S<sub>5</sub> - 75% dosage of EPoE Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> at 15 DAS *fb* POE Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 2; S<sub>6</sub> - 50% dosage of EPoE Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> at 15 DAS *fb* POE Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 3; S<sub>7</sub>– Recommended practice (PE Pendimethalin @ 1 kg a.i ha<sup>-1</sup> at 3 DAS + 1 HW on 40 DAS); S<sub>8</sub>– Unweeded control

**Table 2:** Effect of herbicide mixtures under weed detection techniques on weed dry matter at 60 DAS (no. m<sup>-2</sup>) in cotton during 2019-20

Treatment	Grass				Broad leaved weed				Sedge			
	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean
S <sub>1</sub>	7.4 (54.3)	6.81 (46)	6.74 (45)	6.98 (48.44)	13.55 (183.1)	10.77 (115.57)	10.72 (114.42)	11.68 (137.7)	4.79 (22.47)	3.92 (14.93)	3.82 (14.09)	4.18 (17.17)
S <sub>2</sub>	7.48 (55.47)	6.92 (47.49)	6.8 (45.86)	7.07 (49.61)	13.71 (187.55)	10.95 (119.43)	10.82 (116.66)	11.82 (141.22)	5.02 (24.73)	4 (15.52)	3.96 (15.21)	4.33 (18.49)
S <sub>3</sub>	7.68 (58.55)	7.15 (50.67)	7.08 (49.73)	7.3 (52.98)	14.62 (213.28)	11.59 (133.85)	11.44 (130.41)	12.55 (159.18)	5.41 (28.86)	4.27 (17.93)	4.29 (17.73)	4.66 (21.5)
S <sub>4</sub>	5.99 (35.39)	5.92 (34.57)	5.87 (33.96)	5.92 (34.64)	10.8 (116.25)	10.52 (110.36)	10.48 (109.33)	10.6 (111.98)	3.59 (12.45)	3.5 (11.76)	3.5 (11.78)	3.53 (12)
S <sub>5</sub>	7.23 (51.83)	4.36 (18.5)	3.06 (8.91)	4.88 (26.41)	12.65 (159.77)	8.66 (74.62)	7.09 (49.89)	9.47 (94.76)	4.07 (16.08)	2.75 (7.11)	2.19 (4.3)	3 (9.16)
S <sub>6</sub>	7.59 (57.17)	7.15 (50.64)	6.98 (48.31)	7.24 (52.04)	14.4 (207.02)	11.37 (128.97)	11.17 (124.47)	12.32 (153.49)	5.18 (26.43)	4.1 (16.34)	4.02 (15.7)	4.43 (19.49)
S <sub>7</sub>	6.77 (45.44)	5.66 (31.53)	4.53 (20.04)	5.65 (32.34)	10.94 (119.37)	10.21 (103.91)	9.26 (85.43)	10.14 (102.9)	3.67 (13)	3.4 (11.07)	3.09 (9.07)	3.39 (11.05)
S <sub>8</sub>	19.27 (370.98)	18.75 (351.2)	18.39 (337.89)	18.8 (353.36)	18.71 (349.83)	18.45 (339.92)	18.28 (333.99)	18.48 (341.25)	7.85 (61.12)	7.72 (59.12)	7.52 (56.17)	7.7 (58.81)
Mean	8.68 (91.14)	7.84 (78.83)	7.43 (73.71)		13.67 (192.02)	11.56 (140.83)	11.16 (133.08)		4.95 (25.64)	4.21 (19.22)	4.05 (18.01)	
	M	S	M x S	S x M	M	S	M x S	S x M	M	S	M x S	S x M
SEd	0.22	0.34	0.59	0.59	0.14	0.33	0.55	0.57	0.06	0.16	0.26	0.27
CD (p=0.05)	0.61	0.69	1.27	1.19	0.41	0.66	1.15	1.15	0.16	0.32	0.55	0.56

M<sub>1</sub> –Manual method; M<sub>2</sub> –Image detection with manually operated camera; M<sub>3</sub> – Image detection with drone camera; S<sub>1</sub>– 100% dosage of EPoE Propaquizafop @ 100 g a.i. ha<sup>-1</sup> at 15 DAS *fb* POE Fenoxaprop ethyl @ 67.5 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 1; S<sub>2</sub>– 75% dosage of EPoE Propaquizafop @ 100 g a.i. ha<sup>-1</sup> at 15 DAS *fb* POE Fenoxaprop ethyl @ 67.5 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 2; S<sub>3</sub>– 50% dosage of EPoE Propaquizafop @ 100 g a.i. ha<sup>-1</sup> at 15 DAS *fb* POE Fenoxaprop ethyl @ 67.5 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 3; S<sub>4</sub>– 100% dosage of EPoE Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> at 15 DAS *fb* POE Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 1; S<sub>5</sub> - 75% dosage of EPoE Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> at 15 DAS *fb* POE Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 2; S<sub>6</sub> - 50% dosage of EPoE Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> at 15 DAS *fb* POE Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 3; S<sub>7</sub>– Recommended practice (PE Pendimethalin @ 1 kg a.i ha<sup>-1</sup> at 3 DAS + 1 HW on 40 DAS); S<sub>8</sub>– Unweeded control

**Table 3:** Effect of herbicide mixtures under weed detection techniques on weed indices in cotton during 2019-20

Treatment	Weed control efficiency (WCE) %				Herbicide efficiency index (HEI) %			
	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Mean
S <sub>1</sub>	66.8	77.4	77.8	74.0	2.87	5.61	5.79	4.75
S <sub>2</sub>	65.8	76.7	77.3	73.2	2.68	5.41	5.61	4.57
S <sub>3</sub>	61.5	74.1	74.7	70.1	2.17	4.20	4.71	3.69
S <sub>4</sub>	79.0	80.0	80.2	79.7	6.57	7.04	7.17	6.93
S <sub>5</sub>	70.9	87.2	91.9	83.3	3.50	14.20	26.76	14.82
S <sub>6</sub>	62.8	74.9	75.9	71.2	2.33	4.46	5.13	3.97
S <sub>7</sub>	77.3	81.3	85.4	81.3	5.68	7.68	10.84	8.07
S <sub>8</sub>	-	4.1	6.9	3.6	0.00	0.16	0.20	0.12

Mean	60.5	69.4	71.2		3.22	6.10	8.28	
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Data not statistically analysed

M<sub>1</sub> –Manual method; M<sub>2</sub> –Image detection with manually operated camera; M<sub>3</sub> – Image detection with drone camera; S<sub>1</sub>– 100% dosage of EPoE Propaquizafop @ 100 g a.i. ha<sup>-1</sup> at 15 DAS *fb* POE Fenoxaprop ethyl @ 67.5 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 1; S<sub>2</sub>– 75% dosage of EPoE Propaquizafop @ 100 g a.i. ha<sup>-1</sup> at 15 DAS *fb* POE Fenoxaprop ethyl @ 67.5 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 2; S<sub>3</sub>– 50% dosage of EPoE Propaquizafop @ 100 g a.i. ha<sup>-1</sup> at 15 DAS *fb* POE Fenoxaprop ethyl @ 67.5 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 3; S<sub>4</sub>– 100% dosage of EPoE Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> at 15 DAS *fb* POE Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 1; S<sub>5</sub> - 75% dosage of EPoE Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> at 15 DAS *fb* POE Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 2; S<sub>6</sub> - 50% dosage of EPoE Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> at 15 DAS *fb* POE Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> at 40 DAS based on weed rating 3; S<sub>7</sub> – Recommended practice (PE Pendimethalin @ 1 kg a.i ha<sup>-1</sup> at 3 DAS + 1 HW on 40 DAS); S<sub>8</sub> – Unweeded control

**Table 4:** Effect of herbicide mixtures under weed detection techniques on Yield and Economics of cotton during 2019-20

Treatments	Seed cotton yield (kg ha <sup>-1</sup> )	Net return (₹ ha <sup>-1</sup> )	B:C Ratio
M <sub>1</sub> S <sub>1</sub> – MWD + 100% of EPoE Pq at 15 DAS <i>fb</i> PoE Fp 67.5 gm a.i ha <sup>-1</sup> at 40 DAS	1083	18091	1.415
M <sub>1</sub> S <sub>2</sub> – MWD + 75% of EPoE Pq at 15 DAS <i>fb</i> PoE Fp at 40 DAS	1063	17960	1.423
M <sub>1</sub> S <sub>3</sub> – MWD + 50% of EPoE Pq at 15 DAS <i>fb</i> PoE Fp at 40 DAS	1016	16304	1.393
M <sub>1</sub> S <sub>4</sub> – MWD + 100% of EPoE Q + Py at 15 DAS <i>fb</i> PoE Fl + Fp 40 gm ai at 40 DAS	1319	28434	1.607
M <sub>1</sub> S <sub>5</sub> – MWD + 75% of EPoE Q + Py at 15 DAS <i>fb</i> PoE Fl + Fp 40 gm ai at 40 DAS	1119	18765	1.417
M <sub>1</sub> S <sub>6</sub> – MWD + 50% of EPoE Q + Py at 15 DAS <i>fb</i> PoE Fl + Fp 40 gm ai at 40 DAS	1034	15690	1.364
M <sub>1</sub> S <sub>7</sub> – MWD + PE Pendimethalin @ 1 kg ha <sup>-1</sup> at 3 DAS + 1 HW on 40 DAS	1271	25843	1.554
M <sub>1</sub> S <sub>8</sub> – MWD + Unweeded control	554	-6862	0.821
M <sub>2</sub> S <sub>1</sub> – MCWD + 100% of EPoE Pq at 15 DAS <i>fb</i> PoE Fp 67.5 gm a.i ha <sup>-1</sup> at 40 DAS	1256	28562	1.664
M <sub>2</sub> S <sub>2</sub> – MCWD + 75% of EPoE Pq at 15 DAS <i>fb</i> PoE Fp at 40 DAS	1255	28607	1.667
M <sub>2</sub> S <sub>3</sub> – MCWD + 50% of EPoE Pq at 15 DAS <i>fb</i> PoE Fp at 40 DAS	1157	23020	1.538
M <sub>2</sub> S <sub>4</sub> – MCWD + 100% of EPoE Q + Py at 15 DAS <i>fb</i> PoE Fl + Fp 40 gm ai at 40 DAS	1336	32095	1.726
M <sub>2</sub> S <sub>5</sub> – MCWD + 75% of EPoE Q + Py at 15 DAS <i>fb</i> PoE Fl + Fp 40 gm ai at 40 DAS	1564	45267	2.028
M <sub>2</sub> S <sub>6</sub> – MCWD + 50% of EPoE Q + Py at 15 DAS <i>fb</i> PoE Fl + Fp 40 gm ai at 40 DAS	1174	23682	1.549
M <sub>2</sub> S <sub>7</sub> – MCWD + PE Pendimethalin @ 1 kg ha <sup>-1</sup> at 3 DAS + 1 HW on 40 DAS	1352	30515	1.654
M <sub>2</sub> S <sub>8</sub> – MCWD + Unweeded control	639	-2028	0.947
M <sub>3</sub> S <sub>1</sub> – DWD + 100% of EPoE Pq at 15 DAS <i>fb</i> PoE Fp 67.5 gm a.i ha <sup>-1</sup> at 40 DAS	1266	25352	1.541
M <sub>3</sub> S <sub>2</sub> – DWD + 75% of EPoE Pq at 15 DAS <i>fb</i> PoE Fp at 40 DAS	1261	25191	1.539
M <sub>3</sub> S <sub>3</sub> – DWD + 50% of EPoE Pq at 15 DAS <i>fb</i> PoE Fp at 40 DAS	1214	22377	1.478
M <sub>3</sub> S <sub>4</sub> – DWD + 100% of EPoE Q + Py at 15 DAS <i>fb</i> PoE Fl + Fp 40 gm ai at 40 DAS	1343	29080	1.611
M <sub>3</sub> S <sub>5</sub> – DWD + 75% of EPoE Q + Py at 15 DAS <i>fb</i> PoE Fl + Fp 40 gm ai at 40 DAS	1752	52384	2.100
M <sub>3</sub> S <sub>6</sub> – DWD + 50% of EPoE Q + Py at 15 DAS <i>fb</i> PoE Fl + Fp 40 gm ai at 40 DAS	1240	23429	1.496
M <sub>3</sub> S <sub>7</sub> – DWD + PE Pendimethalin @ 1 kg ha <sup>-1</sup> at 3 DAS + 1 HW on 40 DAS	1435	35307	1.757
M <sub>3</sub> S <sub>8</sub> – DWD + Unweeded control	658	-952	0.975

MWD - Manual weed detection; MCWD – Manual camera weed detection; DWD – Drone camera weed detection; EPoE – Early post emergence; PoE-Post emergence; PE – Pre emergence; *fb*-followed by; Pq-Propaquizafop @ 100 g a.i. ha<sup>-1</sup>; Fp – Fenoxoprop; Q – Quizalofop @ 50 g a.i ha<sup>-1</sup>; Py - Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup>; Fl - Fluazifop @ 140 g a.i ha<sup>-1</sup>; DAS – Days after sowing; HW – Hand weeding

#### 4. Conclusion

It may be conclusively inferred from present investigation that the detection of weeds through drone images with the application of 75% dosage of Quizalofop ethyl @ 50 g a.i ha<sup>-1</sup> + Pyriithiobac Sodium @ 62.5 g a.i ha<sup>-1</sup> as early post emergence herbicide on 15 DAS followed by Post emergence application of Fluazifop butyl @ 140 g a.i ha<sup>-1</sup> + Fenoxaprop ethyl @ 40 g a.i. ha<sup>-1</sup> on 40 DAS based on weed rating have good control over weeds and exhibits higher bio efficacy compared to the other herbicide mixtures in Cotton at Tamil Nadu.

#### 5. References

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