



# Effect of Herbigation on Weed Control and Yield of Drip Irrigated Cotton

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

## Article Information

DOI: 10.9734/IJPSS/2023/v35i214071

## Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/108989>

Original Research Article

Received: 01/09/2023

Accepted: 07/11/2023

Published: 08/11/2023

## ABSTRACT

A field experiment was conducted during *Summer*, 2023 at Anbil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Tiruchirappalli to study the effect of herbigation on weed control and yield of drip irrigated cotton. The experiment was laid out in randomized block design with nine treatments and replicated thrice. The treatments consisted of herbigation of pre emergence (PE) herbicides (Pendimethalin 1.0 kg ha<sup>-1</sup> and Oxyfluorfen 0.2 kg ha<sup>-1</sup>) combined with hand weeding at 45 DAS or manual spray or herbigation of post emergence (PoE) herbicide (Pyriathiobac Sodium + Quizalofop Ethyl 75 g ha<sup>-1</sup> on 25 DAS) compared with

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recommended practice of manual spray of PE pendimethalin 1.0 kg ha<sup>-1</sup> + HW at 45 DAS, HW twice on 20 and 40 DAS and unweeded control. The results revealed that among the different weed management practices manual spray of PE pendimethalin 1.0 kg ha<sup>-1</sup> + HW at 45 DAS registered significantly lower total weed density (12.63 m<sup>-2</sup>), total weed dry weight (8.23 g m<sup>-2</sup>) and higher weed control efficiency (77%) at 20 DAS. This was followed by herbigation of PE pendimethalin 1.0 kg ha<sup>-1</sup> + manual spray of PoE pyriithiobac sodium + quizalofop ethyl 75 g ha<sup>-1</sup> on 25 DAS. Among the herbigation treatments, herbigation of PE pendimethalin 1.0 kg ha<sup>-1</sup> + manual spray of PoE pyriithiobac sodium + quizalofop ethyl 75 g ha<sup>-1</sup> on 25 DAS obtained lower total weed density (12.13 m<sup>-2</sup>), total weed dry weight (9.19 g m<sup>-2</sup>) and higher WCE (86%) at 40 DAS. This was followed by herbigation of PE oxyfluorfen 0.2 kg ha<sup>-1</sup> + manual spray of PoE pyriithiobac sodium + quizalofop ethyl 75 g ha<sup>-1</sup> on 25 DAS. At 60 DAS, application of manual spray of PE pendimethalin 1.0 kg ha<sup>-1</sup> + HW at 45 DAS recorded lower total weed density (18.07 m<sup>-2</sup>), total weed dry weight (16.03 g m<sup>-2</sup>) and higher weed control efficiency (85%). However, this was comparable with herbigation of PE pendimethalin 1.0 kg ha<sup>-1</sup> + manual spray of PoE pyriithiobac sodium + quizalofop ethyl 75 g ha<sup>-1</sup> on 25 DAS and HW on 20 and 40 DAS. The highest seed cotton yield (2109 kg ha<sup>-1</sup>) was obtained with manual spray of PE pendimethalin 1.0 kg ha<sup>-1</sup> + HW at 45 DAS and it was on par with herbigation of PE pendimethalin 1.0 kg ha<sup>-1</sup> + manual spray of PoE pyriithiobac sodium + quizalofop ethyl 75 g ha<sup>-1</sup> on 25 DAS and HW on 20 and 40 DAS. Hence, considering the labour scarcity, herbigation of PE pendimethalin 1.0 kg ha<sup>-1</sup> on 3 DAS followed by manual spray of PoE pyriithiobac sodium + quizalofop ethyl 75 g ha<sup>-1</sup> on 25 DAS could be recommended for better weed control in drip irrigated cotton.

**Keywords:** Cotton; herbigation; weed management; weed control efficiency; yield.

## 1. INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is one of the most important cash as well as fibre crop in India. It is commonly referred as the “King of Fibre” and “White Gold”. It contributes up to 75 per cent of the total raw material demands of the textile industry and it is crucial to economic and commercial operations in both rural and urban areas of the nation. Currently, cotton provides 6% of the world's protein and 80% of its natural fibres [1]. “In India, cotton is grown in an acreage of 130.61 lakh ha, with a production of 343.47 lakh bales, and a productivity of 447 kg ha<sup>-1</sup> [2]. “Despite the fact that there are several factors that causes reduction in cotton production, the primary key factor that lowers cotton yield is weed. The critical period of weed competition in cotton is upto 45 DAS. Weeds are fiercely competing with cotton crop for space, light, nutrients and moisture” [3]. “Weed infestation is one of the most serious threats to cotton cultivation and causes yield loss of 40-85 per cent” [4]. “The most effective way to manage weeds is by hand weeding” [5]. “However, this method is expensive, time-consuming, and difficult. Hence herbicidal weed management is necessary during the peak period of weed infestation due to a shortage of labour and rising labour costs” [6]. “Although there are numerous pre and post-emergence herbicides available for weed control, the complex weed flora in cotton

needs the use of a combination of pre and post emergence herbicides for effectively manage weeds during the critical period of crop weed competition” [4]. “Herbigation is an effective method for application of herbicides through drip irrigation” [7] and [8]. Labour scarcity for herbicide spraying, health issues due to manual spray and escalation of labour wages force the farmers to seek alternate method of herbicide application in cotton. Since cotton cultivation under drip irrigation is increasing day by day due to water scarcity, application of herbicides through drip could be a viable option for cotton growers. However studies on herbigation in cotton were completely lacking. Hence, the present investigation was undertaken to study the influence of herbigation on weed control and yield of drip irrigated cotton.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site

The field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli during Summer, 2023. The experimental site is located at 10° 45' N latitude, 78° 36' E longitude, and 85 m above mean sea level. The soil of the experimental field was sandy clay loam in texture, moderately drained and classified as *Vetric Ustropept* with pH of 8.7 and EC of 0.57 dS m<sup>-1</sup>.

## 2.2 Experiment Details

The experiment was laid out in randomized block design with nine treatments and replicated thrice. The treatments consisted of herbigation of PE pendimethalin 1.0 kg ha<sup>-1</sup> + Hand Weeding (HW) at 45 DAS, herbigation of PE oxyfluorfen 0.2 kg ha<sup>-1</sup> + HW at 45 DAS, herbigation of PE pendimethalin 1.0 kg ha<sup>-1</sup> + manual spray of PoE pyriithiobac sodium + quizalofop ethyl 75 g ha<sup>-1</sup> on 25 DAS, herbigation of PE oxyfluorfen 0.2 kg ha<sup>-1</sup> + manual spray of PoE pyriithiobac sodium + quizalofop ethyl 75 g ha<sup>-1</sup> on 25 DAS, herbigation of PE pendimethalin 1.0 kg ha<sup>-1</sup> + herbigation of PoE pyriithiobac sodium + quizalofop ethyl 75 g ha<sup>-1</sup> on 25 DAS, herbigation of PE oxyfluorfen 0.2 kg ha<sup>-1</sup> + herbigation of PoE pyriithiobac sodium + quizalofop ethyl 75 g ha<sup>-1</sup> on 25 DAS, manual spray of PE pendimethalin 1.0 kg ha<sup>-1</sup> + HW at 45 DAS, HW on 20 and 40 DAS and unweeded control. Cotton variety SVPR 6 was sown at a spacing of 60 X 30 cm. The drip irrigation system was laid out with lateral spacing of 60 cm and dripper spacing of 60 cm. The discharge rate of dripper was 1.5 lit/hour.

## 2.3 Observation on Weeds

“The total weed density and weed dry weight were observed on 20, 40 and 60 DAS. The weed density was recorded using quadrat from four places in each plot and the mean values were expressed in number m<sup>-2</sup>. The collected weeds were shade dried and later dried in hot air oven at 80°C for 72 hrs. The total dry weight of weeds was expressed in g m<sup>-2</sup>.”

Data on weed density and dry weight had high variation and were subjected to square root transformation ( $\sqrt{X+0.5}$ ) and analyzed statistically. Critical difference (CD) at five per cent level of probability was calculated for comparison. Non significant comparison was indicated as ‘NS’ [9].

Weed control efficiency was calculated at 20, 40 and 60 DAS by using the method [10].

$$\text{WCE} = \left( \frac{\text{Total weed dry weight in unweeded control plot (g m}^{-2}\text{)} - \text{Total weed dry weight in treated plot (g m}^{-2}\text{)}}{\text{Total weed dry weight in unweeded control (g m}^{-2}\text{)}} \right) \times 100$$

## 2.4 Observation on Yield

Seed cotton yield was recorded from net plot area and expressed in kg ha<sup>-1</sup>.

## 3. RESULTS AND DISCUSSION

### 3.1 Weed Flora

The predominant weed species found in the experimental field were *Chloris barbata*, *Cynodon dactylon*, *Dactyloctenium aegypticum*, *Echinochloa colona* in grasses, *Cyperus iria* in sedges, *Acalypha indica*, *Trianthema portulacastrum* and *Tridax procumbens* in broad leaved weeds. A similar weed flora was observed by [11], [12], [13] and [14].

### 3.2 Effect of Weed Management on Total Weed Density and Weed Dry Weight

The total weed density and weed dry weight were significantly influenced by various weed management practices (Table 1). Among the weed management techniques in drip irrigated cotton at 20 DAS, the lowest total weed density (12.63 m<sup>-2</sup>) and weed dry weight (8.23 g m<sup>-2</sup>) were recorded in manual spray of PE pendimethalin 1.0 kg ha<sup>-1</sup> + HW at 45 DAS. “However, it was followed by herbigation of PE pendimethalin 1.0 kg ha<sup>-1</sup> + manual spray of PoE pyriithiobac sodium + quizalofop ethyl 75 g ha<sup>-1</sup> on 25 DAS, herbigation of PE pendimethalin 1.0 kg ha<sup>-1</sup> + HW at 45 DAS and herbigation of PE pendimethalin 1.0 kg ha<sup>-1</sup> + herbigation of PoE pyriithiobac sodium + quizalofop ethyl 75 g ha<sup>-1</sup> on 25 DAS. This could be due to the effective control of weeds in the initial stages with application of pre emergence herbicides. This might be due to drip irrigation is scheduled every other day, the soil is always wet, and thorough wetting of the surface soil makes it easier for herbicide molecules to spread throughout the soil, which showed that herbigation significantly reduced weed growth and weed dry weight on 20 DAS” [15].

Herbigation of PE pendimethalin 1.0 kg ha<sup>-1</sup> + manual spray of PoE pyriithiobac sodium + quizalofop ethyl 75 g ha<sup>-1</sup> on 25 DAS registered significantly lower total weed density (12.13 m<sup>-2</sup>), weed dry weight (9.19 g m<sup>-2</sup>) at 40 DAS. This was followed by herbigation of PE oxyfluorfen 0.2 kg ha<sup>-1</sup> + manual spray of PoE pyriithiobac sodium + quizalofop ethyl 75 g ha<sup>-1</sup> on 25 DAS. This is mainly because of Acetolactate Synthase inhibition (ALS) in PoE pyriithiobac sodium [16] plus quizalofop ethyl is an inhibitor of fatty acids synthesis through Acetyl-CoA Carboxylase (ACCCase) inhibition [17] and it greatly reduced the both grassy and broad leaved weeds.

**Table 1. Effect of weed management practices on total weed density and weed dry weight in drip irrigated cotton**

Treatments	Total weed density (No./m <sup>2</sup> )			Total weed dry weight (g/m <sup>2</sup> )		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
T <sub>1</sub> - Herbigation of PE Pendimethalin 1.0 kg ha <sup>-1</sup> + HW at 45 DAS	4.20 (17.11)	5.57 (30.52)	5.01 (24.48)	3.26 (10.10)	5.01 (24.56)	4.81 (22.68)
T <sub>2</sub> - Herbigation of PE Oxyfluorfen 0.2 kg ha <sup>-1</sup> + HW at 45 DAS	5.28 (27.39)	6.81 (45.88)	7.14 (50.53)	5.20 (26.56)	6.64 (43.56)	6.46 (41.18)
T <sub>3</sub> - Herbigation of PE Pendimethalin 1.0 kg ha <sup>-1</sup> + manual spray of PoE Pyrithiobac sodium + Quizalofop ethyl 75 g ha <sup>-1</sup> on 25 DAS	4.17 (16.88)	3.55 (12.13)	4.48 (19.57)	3.14 (9.34)	3.11 (9.19)	4.24 (17.45)
T <sub>4</sub> - Herbigation of PE Oxyfluorfen 0.2 kg ha <sup>-1</sup> +manual spray of PoE Pyrithiobac sodium + Quizalofop ethyl 75 g ha <sup>-1</sup> on 25 DAS	5.33 (27.92)	4.33 (18.27)	7.86 (61.23)	5.24 (27.00)	3.81 (14.01)	7.32 (53.14)
T <sub>5</sub> - Herbigation of PE Pendimethalin 1.0 kg ha <sup>-1</sup> + herbigation of PoE Pyrithiobac sodium + Quizalofopethyl 75 g ha <sup>-1</sup> on 25 DAS	4.32 (18.14)	5.64 (31.28)	8.77 (76.38)	3.32 (10.52)	5.31 (27.74)	8.16 (66.02)
T <sub>6</sub> - Herbigation of PE Oxyfluorfen0.2 kg ha <sup>-1</sup> + herbigation of PoE Pyrithiobac sodium + Quizalofop ethyl 75 g ha <sup>-1</sup> on 25 DAS	5.39 (28.58)	6.84 (46.35)	9.58 (91.33)	5.25 (27.11)	6.82 (46.01)	8.84 (77.66)
T <sub>7</sub> - Manual spray of PE Pendimethalin 1.0 kg ha <sup>-1</sup> + HW at 45 DAS	3.62 (12.63)	5.17 (26.18)	4.31 (18.07)	2.95 (8.23)	4.42 (19.00)	4.07 (16.03)
T <sub>8</sub> - HW on 20 and 40 DAS	6.22 (38.16)	5.11 (25.63)	4.65 (21.12)	6.07 (36.34)	4.30 (17.95)	4.59 (20.55)
T <sub>9</sub> - Unweeded control	6.25 (38.62)	8.51 (71.88)	10.39 (107.41)	6.12 (37.01)	8.26 (67.75)	10.36 (106.84)
<b>CD (P=0.05)</b>	0.42	0.52	0.61	0.47	0.54	0.58

*Figure in parentheses are original values*

**Table 2. Effect of weed management practices on weed control efficiency and seed cotton yield in drip irrigated cotton**

Treatments	WCE (%)*			Seed cotton yield (kg ha <sup>-1</sup> )
	20 DAS	40 DAS	60 DAS	
T <sub>1</sub> - Herbigation of PE Pendimethalin 1.0 kg ha <sup>-1</sup> + HW at 45 DAS	72.7	63.7	78.5	1828
T <sub>2</sub> - Herbigation of PE Oxyfluorfen 0.2 kg ha <sup>-1</sup> + HW at 45 DAS	28.2	35.6	61.4	1559
T <sub>3</sub> - Herbigation of PE Pendimethalin 1.0 kg ha <sup>-1</sup> + manual spray of PoE Pyriithiobac sodium + Quizalofop ethyl 75 g ha <sup>-1</sup> on 25 DAS	74.6	86.4	83.7	2068
T <sub>4</sub> - Herbigation of PE Oxyfluorfen 0.2 kg ha <sup>-1</sup> + manual spray of PoE Pyriithiobac sodium + Quizalofop ethyl 75 g ha <sup>-1</sup> on 25 DAS	27.0	79.3	50.2	1412
T <sub>5</sub> - Herbigation of PE Pendimethalin 1.0 kg ha <sup>-1</sup> + herbigation of PoE Pyriithiobac sodium + Quizalofop ethyl 75 g ha <sup>-1</sup> on 25 DAS	71.6	59.0	38.2	1270
T <sub>6</sub> - Herbigation of PE Oxyfluorfen 0.2 kg ha <sup>-1</sup> + herbigation of PoE Pyriithiobac sodium + Quizalofop ethyl 75 g ha <sup>-1</sup> on 25 DAS	26.7	32.1	27.3	944
T <sub>7</sub> - Manual spray of PE Pendimethalin 1.0 kg ha <sup>-1</sup> + HW at 45 DAS	77.8	71.9	85.0	2109
T <sub>8</sub> - HW on 20 and 40 DAS	1.8	73.5	80.7	1965
T <sub>9</sub> - Unweeded control	-	-	-	721
<b>CD (P=0.05)</b>	-	-	-	<b>137</b>

\*Data not statistically analyzed

At 60 DAS, the lowest total weed density ( $18.07\text{m}^{-2}$ ) and total weed dry weight ( $16.03\text{ g m}^{-2}$ ) were noticed in manual spray of PE pendimethalin  $1.0\text{ kg ha}^{-1}$  + HW at 45DAS. However, it was comparable with herbigation of PE pendimethalin  $1.0\text{ kg ha}^{-1}$  + manual spray of PoE pyriithiobac sodium + quizalofop ethyl  $75\text{ g ha}^{-1}$  on 25 DAS and HW on 20 and 40 DAS. This might be attributed to pendimethalin enters grasses through coleoptiles and shoot of seedlings below the ground level [18] and it had rapid depletion of carbohydrates reserves of weeds through rapid respiration [19] it leads to decreased weed density and dry weight of weeds [20]. The unweeded control has recorded higher total weed density and weed dry weight in drip irrigated cotton at all stages of observation.

### 3.3 Effect of Weed Management on Weed Control Efficiency

Weed control efficiency at different stages of crop growth varied with weed management methods (Table 2). At 20 DAS, manual spray of PE pendimethalin  $1.0\text{ kg ha}^{-1}$  at 3 DAS + HW on 45 DAS registered more than 75% weed control efficiency. This was followed by herbigation of PE pendimethalin  $1.0\text{ kg ha}^{-1}$  + manual spray of PoE pyriithiobac sodium + quizalofop ethyl  $75\text{ g ha}^{-1}$  on 25 DAS, herbigation of PE pendimethalin  $1.0\text{ kg ha}^{-1}$  + HW at 45 DAS and herbigation of PE pendimethalin  $1.0\text{ kg ha}^{-1}$  + herbigation of PoE pyriithiobac sodium + quizalofop ethyl  $75\text{ g ha}^{-1}$  on 25 DAS. "All the weed management treatments decreased the weed population compared to a weedy check resulted in improved weed control efficiency" [21].

At 40 DAS, the highest weed control efficiency (86%) was obtained with herbigation of PE pendimethalin  $1.0\text{ kg ha}^{-1}$  + manual spray of PoE pyriithiobac sodium + quizalofop ethyl  $75\text{ g ha}^{-1}$ . However, this was followed by herbigation of PE oxyfluorfen  $0.2\text{ kg ha}^{-1}$  + manual spray of PoE pyriithiobac sodium + quizalofop Ethyl  $75\text{ g ha}^{-1}$  on 25 DAS. This might be due to quizalofop ethyl are ACCase inhibitors, which inhibit the enzyme Acetyl CoA Carboxylase [16]. "This might be due to lesser competition of weeds achieved by effective control of first and second flush of weeds which resulted in reduction in total weed density and weed dry weight. Application of pre emergence herbicide along with post emergence herbicide effectively reduced the weed biomass" [14].

"At 60 DAS, significantly recorded higher WCE (85%) in manual spray of PE pendimethalin  $1.0$

$\text{kg ha}^{-1}$  + HW at 45 DAS and it was on par with herbigation of PE pendimethalin  $1.0\text{ kg ha}^{-1}$  + manual spray of POE pyriithiobac sodium + quizalofop ethyl  $75\text{ g ha}^{-1}$  on 25 DAS and hand weeding twice at 20 and 40 DAS. Application of pre-emergence pendimethalin and post emergence pyriithiobac sodium + quizalofop ethyl controlled the weeds in broad spectrum which resulted in lower weed density and greater weed control efficiency" [22].

### 3.4 Effect on Seed Cotton Yield

Seed cotton yield was significantly influenced by various weed management techniques (Table 2). The highest seed cotton yield was obtained in manual spray of PE pendimethalin  $1.0\text{ kg ha}^{-1}$  + HW at 45 DAS ( $2109\text{ kg ha}^{-1}$ ). The highest seed cotton yield might be to effective control of weeds by using herbicides with hand weeding which resulted better nourishment of growth and seed cotton yield [23,24]. However, it was on par with herbigation of PE pendimethalin  $1.0\text{ kg ha}^{-1}$  + manual spray of PoE pyriithiobac sodium + quizalofop ethyl  $75\text{ g ha}^{-1}$  on 25 DAS ( $2068\text{ kg ha}^{-1}$ ) and hand weeding twice at 20 and 40 DAS ( $1965\text{ kg ha}^{-1}$ ). This is mainly due to application of PE pendimethalin either by herbigation or manual spray at 3 DAS had significant effect of preventing the emergence of the first flush of weeds. Pendimethalin primarily enters through microtubule and inhibiting cell division resulted in considerable decrease in weed density and dry weight, reduction in depletion of nutrients by weeds, favoured better crop growth and seed cotton yield [22]. The second flushes of weeds were controlled by a ready mix of pyriithiobac sodium + quizalofop ethyl resulted in lesser weed competition of grassy and broad leaved weeds. Sequential application of both PE pendimethalin and PoE pyriithiobac sodium + quizalofop ethyl found to be in effective in controlling weeds during critical period crop growth, led to the optimal utilisation of resources and nutrient uptake by cotton [25], which ultimately increased the seed cotton yield ( $2068\text{ kg ha}^{-1}$ ) [18], [19]. The lowest seed cotton yield ( $721\text{ kg ha}^{-1}$ ) was recorded in unweeded control.

## 4. CONCLUSION

From this study, it could be concluded manual spray of PE pendimethalin  $1.0\text{ kg ha}^{-1}$  + HW at 45 DAS or herbigation of PE pendimethalin  $1.0\text{ kg ha}^{-1}$  + manual spray of PoE pyriithiobac sodium + quizalofop ethyl  $75\text{ g ha}^{-1}$  on 25 DAS recorded the highest weed control as well as seed cotton yield.

Conventional method of weed control takes considerable time and labour. Hence under increasing labour scarcity condition, herbigation of PE pendimethalin 1.0 kg ha<sup>-1</sup> on 3 DAS followed by manual spray of PoE pyriithiobac sodium + quizalofop ethyl 75 g ha<sup>-1</sup> on 25 DAS could be recommended for better weed control and increased seed cotton yield.

## ACKNOWLEDGEMENTS

The author acknowledge the Director, Centre for Water and Geospatial Studies, TNAU, Coimbatore for providing research fellowship under the scheme of CCX (Core Carbon X) during my course of investigation.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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