https://doi.org/10.48047/AFJBS.6.14.2024.9736-9749

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Evaluating Bio-efficacy of Early Post-Emergence Herbicides on Weed Control, Yield, and Economic Outcomes in *Bt* Cotton (*Gossypium hirsutum* L.)

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Volume 6, Issue 14, Aug 2024

Received: 15 June 2024

Accepted: 25 July 2024

Published: 15 Aug 2024

doi: 10.48047/AFJBS.6.14.2024.9736-9749

Abstract

A field experiment was conducted at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, in the rainy (*kharif*) season to study the bio- efficacy of various early post-emergence (EPoE) herbicides against weeds in cotton. The experiment consisted of eleven treatments (including the one only for phytotoxicity studies), replicated three times, and laid out in a randomized block design. The various treatments that were incurred in this experimental study were pyrithiobac-sodium 7.5%+ haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC at 650, 825, 1000, and 1650 (only for phytotoxicity study) ml ha^{-1} as EPoE, pyrithiobac-sodium 10% EC at 750 ml ha^{-1} as EPoE, haloxyfop-R- methyl 10.5%w/w EC at 1250 ml ha^{-1} EPoE, fenoxaprop-p-ethyl 9.3% EC at 750 ml ha^{-1} EPoE, propaquizafop 10% EC at 625 ml ha^{-1} EPoE, hand weeding at 30 and 60 days after sowing (DAS), weed-free and control (water spray). The treatment involving pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC at 1000 ml ha^{-1} EPoE resulted in the lowest weed density and biomass, weed index, and higher weed control efficiency. The phytotoxicity effect was obtained in pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC at a higher dose of 1650 ml ha^{-1}, which was subsequently resolved. This treatment also showed a higher value of growth parameters and yield attributes, *i.e.*, plant height, number of sympodial branches, green bolls, and picked bolls per plant, ultimately leading to a 60% increase in yield compared to the weedy control. A higher net return and B-C ratio were also obtained in this treatment.

Key words: Cotton, Haloxyfop-R-methyl, Fenoxaprop-p-ethyl, Propaquizafop, Pyrithiobac-sodium, Weed management

INTRODUCTION

Cotton is a significant fiber and cash crop in India, also known as the 'white gold' or 'money spinner'. India ranks first across the world in acreage of cotton, with 124 lakh hectares of areadevoted to cotton cultivation, which is approximately 39% of the total area under cotton cultivation across the globe. It plays a crucial role by providing substantial employment to 6 million cotton farmers and 40 to 50 million people engaged in cotton processing and trading nationwide. India also records as the 2nd largest producer with 323.11 lakh bales (5.50 millionmetric tons) of estimated production in the cotton season 2023-24, which is about 24% of the global cotton production.

However, in terms of productivity, India ranks 33rd with 441 kg ha^{-1} yield (Government of India, 2024). Among the many challenges faced by cotton farmers, weed infestation is prominent, leading to reduced yields of up to 30 to 90% due to poor crop stand (Singh, 2014). Weeds compete with the crop for nutrients, light, moisture, and space, and they also act as an alternate host for insects and diseases. Cotton, being widely spaced and slow to grow, competes intensely with weeds, particularly needing a weed-free period during the initial 9 to 11 weeks (Bukun, 2004; Ayyadurai and Poonguzhalan, 2011). While complete weed eradication is not cost-effective, managing weeds becomes essential. Previously, farmers relied on manual and mechanical methods, but due to high labor costs, these were impractical. Chemical weed control emerges as a more affordable and effective solution in comparison. However, due to the varied nature of weed species in cotton fields, using a single herbicide may not suffice. Therefore, combining herbicides or applying them sequentially at different stages is a common practice. This approach aims to enhance farm management, expand weed control capabilities, improve application effectiveness, and combat herbicide resistance. Recently, combinations of pyrithiobac sodium and quizalofop-ethyl have been proven effective against both broad-leaved and narrow-leaved weeds in cotton. Given these considerations, a field experiment was commenced to identify an effective post-emergence herbicide that is crucial for optimal weed management in cotton fields.

MATERIALS AND METHODS

The present field experiment was conducted at the Agricultural Research Farm, Banaras Hindu University, Varanasi, in the *kharif* season of 2023. The research farm is geographically situated on the northern Gangetic alluvial plains at 25°18′ N latitude, 83°03′ E longitude, and an altitude of 75.7 meters above the mean sea level. The soil was sandy clay loam in texture, having a pH of 7.35. The soil of the experimental field was moderately fertile with low organic carbon (0.46%) and available nitrogen (188 kg ha^{-1}), medium in available phosphorus (14 kg ha^{-1}) and available potassium (207 kg ha^{-1}). Eleven treatments (including the one for phytotoxicity studies) were laid out in a randomized block design (RBD) replicated three times. All the herbicides were sprayed as early post-emergence 10 days after sowing, using a knapsack sprayer with a hollow cone nozzle. For efficient spraying of the herbicide formulations, they were mixed with 500 l ha^{-1} of water. For this experiment, the *Bt* cotton (*Gossypium hirsutum* L.) variety 'RCH 653' was used at a seed rate of 5 kg ha^{-1} and 50 cm x 25 cm spacing. Half the dose of nitrogen and the full dose of phosphorous, potash, and sulphur were applied as basal.

seed rate of 5 kg ha^{-1} and 50 cm x 25 cm spacing. Half the dose of nitrogen and the full dose of phosphorous, potash, and sulphur were applied as basal. The remaining dose of nitrogen was applied In the form of urea, diammonium phosphate, muriate of potash, and bentonite sulphur, respectively, the prescribed doses of 100:40:40:20 of N, P_2O_5, K_2O, and S per acre of fertilizer was applied. Basal application of full amounts of phosphorous, potash, and sulphur, and half of the nitrogen dose were done. During the peak flowering stage, the remaining nitrogen dose was administered. Insecticide spirotetramat 11.01% w/w + imidachloprid 11.01 % w/w @ 1 ml l^{-1} was used for the control of sucking pests, especially the outbreak of red cotton bugs. The various treatments that were incurred in this experimental study were pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC at 650, 825, and 1000 ml ha^{-1} applied as early post- emergence (EPoE), pyrithiobac-sodium 10% EC at 750 ml ha^{-1}, haloxyfop-R-methyl 10.5%w/w EC at 1250 ml ha^{-1} (EPoE), fenoxaprop-p-ethyl 9.3% EC at 750 ml ha^{-1} (EPoE), propaquizafop 10% EC at 625 ml ha^{-1} (EPoE), hand weeding at 30 and 60 days after sowing (DAS), weed-free and control (water spray). The application of pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC at 1650 ml ha^{-1} was also taken only for phytotoxicity study due to herbicide action. The data on weed density, weed biomass, growth parameters, yield attributes, and seed cotton yield were recorded and statistically analyzed. Moreover, the economics were also worked out. The weed control efficiency (WCE)was calculated using the following formula given by Mani *et al*. (1973).

$$WCE\ (\%) = \frac{W_C - W_T}{W_C} \times 100$$

Where W_C and W_T are the weed biomass in the control (unweeded) and treated plots, respectively. The weed index (WI) was calculated using the following formula given by Gill and Kumar (1969).

$$WI\ (\%) = \frac{Y_{WF} - Y_T}{Y_{WF}} \times 100$$

Where Y_{WF} and Y_T are the seed yields from the weed-free (hand weeded) and treated plots (kg ha^{-1}). The weed indices such as the herbicide efficiency index (HEI), the weed management index (WMI), and the weed persistence index (WPI), were calculated using formulae as given by Das (2008).

$$\text{HEI (\%)} = \frac{Y_T - Y_C/Y_C}{W_T/W_C}$$

$$\text{WMI (\%)} = \frac{Y_T - Y_C/Y_C}{W_C - W_T/W_C}$$

$$\text{WPI (\%)} = \frac{W_T \text{ x } W_{PC}}{W_C \text{ x } W_{PT}} \times 100$$

Where W_C and W_T are the weed biomass in the control (unweeded) and treated plots; Y_C and Y_T are the seed cotton yields from the control (unweeded) and treated plots (kg ha^{-1}); W_{PT} and W_{PC} are the weed population in the treated plot and control (unweeded) plots, respectively.

RESULTS AND DISCUSSION

Weed flora

The most predominant weeds found in the experimental field were *Cyperus rotundus***,** *Cynodon dactylon*, *Echinochloa colonum*, *Parthenium hysterophorus*, *Trianthema portulacastrum*, and *Phyllanthus niruri* to the degree of 57%, 7%, 13%, 11%, 7%, and 6% respectively when recorded 30 days after treatment application in 2023. Sreena *et al.* (2019) at Tunga-Bhadra region and Nakala *et al.* (2019) in Telangana also found similar weeds associated with cotton crops.

Weed parameters

The data furnished in Table 1 showed that all the treatments resulted in a significant reductionin weed density and biomass as compared to weedy control. The lowest weed density of grasseswas found in early post-emergence (EPoE) application of haloxyfop-R-methyl (1250 ml ha^{-1}),which gave statistically similar results with pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC (1000 ml ha^{-1}) (EPoE). Singh *et al.* (2023) also found asimilar result in black gram that haloxyfop 135 g ha^{-1} PoE found to be superior significantly inreducing the density of *E. colona* at Pantnagar, Uttarakhand. In the case of sedges, propaquizafop (625 ml ha^{-1}) (EPoE), hand weeding at 30 and 60 DAS, pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC (1000 ml ha^{-1}) (EPoE) gavesignificantly lower weed density than other treatments. A similar result was found by Kumar *et al*.

(2018) in a soybean crop at Palampur, where propaquizafop reduced the dry weight of *E. colona*, *C. benghalensis*, and *C. iria* significantly but not of *A. conyzoides* or *P. alatum.* The lowest weed density of broad-leaved weeds was found in the EPoE application of pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC (1000 ml ha^{-1}). The total weed density and biomass were also lowest in the EPoE application of pyrithiobac-sodium 7.5%, haloxyfop-R-methyl 13.5% and fenoxaprop-p-ethyl 1% MEC (1000 ml ha^{-1}). This symbolizes that the herbicide mixture facilitates control of a broader range of weeds and ultimately gives the least weed density and weed biomass. Similar results were also reported by Rao (2011) at Guntur, Andhra Pradesh, while working on post-emergence tank mix application of pyrithiobac-sodium and quizalofop-ethyl, and Veeraputhiran (2023) in Tamil Nadu using pendimethalin PE *fb* pyrithiobac-sodium PoE *fb* one hoeing, which recorded the lesser weed density and biomass. The data (Table 2) directed that among herbicidal treatments, the highest weed control efficiency (WCE) for controlling *Cyperus rotundus* and *Phyllanthus niruri* was shown by propaquizafop (625 ml ha^{-1}) (EPoE). For the control of *Echinochloa colonum*, haloxyfop-R-methyl (1250 ml ha^{-1}) (EPoE) showed the highest WCE. The treatment application involving EPoE application of pyrithiobac alone at 750 ml ha^{-1} showed higher WCE among herbicidal treatments in the case of *Parthenium hysterophorus,* and the treatment application of pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC (1000 ml ha^{-1}) (EPoE) showed the best result of WCE for *Cynodon dactylon* and *Trianthema portulacastrum*. Overall, the treatment pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC (1000 ml ha^{-1}) (EPoE) showed comparatively higher WCE for all the weed species. Similar findings were also reported by Kamble and Danawale (2017) in Maharashtra and Hariharasudhan and Chinnusamy (2018) in Tamil Nadu in two separate trials where pendimethalin at 1.0 kg ha^{-1} or oxyfluorfen at 0.1 $kgha^{-1}$ *fb* pyrithiobac-sodium at 75 g ha^{-1} at 45 days after sowing (DAS), along with one mechanical weeding at 60 DAS, showed higher WCE in cotton crop. The lowest weed index was also found in the case of the treatment where pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC was used at 1000 ml ha-1 (EPoE). This may be due to the higherweed control efficiency of this treatment.

Moreover, this treatment also showed the highest herbicide efficiency index, weed management index, and lowest weed persistence index amongherbicidal treatments, as shown in Fig. 1. Kamble and Danawale . (2017) found similar results in Maharashtra while working with pendimethalin at 1.0 $kgha^{-1}$ or oxyfluorfen at 0.1 $kgha^{-1}$ *fb* pyrithiobac-sodium at 75 g ha^{-1} at 45 DAS, along with one mechanical weeding at 60 DAS in *Bt*. cotton, which gave a lower value of weed index and a higher value of herbicide efficiencyindex and crop resistance index.

Growth parameters and yield attributes

The data presented in Table 3 shows that among the herbicidal treatments, the EPoE application of pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC (T_3) at 1000 ml ha^{-1}, followed by the same treatment at 825 ml ha^{-1}, and propaquizafop 10% EC at 625 ml ha^{-1} (EPoE) showed higher plant height, number of sympodial branches, and number of green bolls per plant. The number of picked bolls per plant increased by 83% in this treatment as compared to the weedy check. This suggests that better control of weeds in these treatments led to less competition from weeds and, finally, a higher value of growth parameters and yield attributes. The weedy check plot had the lowest value for the above growth parameters and yield attributes due to the abundance of weeds since no control measure was taken. A similar observation was also noted by Mathukia *et al.* (2018) in Gujarat, where unweeded checks showed significantly the lowest values of the above. The mean boll weight of $plant^{-1}$ was not significantly affected by the herbicidal treatments. Veeraputhiran (2023) in Tamil Nadu also found a similar result where pendimethalin PE *fb* pyrithiobac-sodium PoE *fb* one hoeing recorded the higher cotton growth and yield attributes except boll weight.

Cotton yields

As per the data presented in Table 3, the highest yield among the herbicidal treatments was observed in the application of pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC at 1000 ml ha^{-1} and the same treatment at 825 ml ha^{-1} as EPoE, which resulted in about 60 and 59% increase in yield over weedy check. While the lowest yield was obtained under a weedy check, this underscores the detrimental impact of weeds on cotton yield. Weeds compete with cotton plants for nutrients, water, and sunlight, thereby reducing their growth and productivity. This indicates that these herbicides effectively managed weed competition, allowing cotton plants to achieve higher yields. Similarly, Nayak *et al.* (2016) in Odisha found a 56.6% reduction in yield in weedy check as compared to pre-emergence application of pendimethalin *fb* sequential application of quizalofop-p-ethyl, supplemented with one hoeing. Nalini and Chinnusamy (2019) also got a similar result at Coimbatore in pre-emergence application of pendimethalin (38.7%) at 2.0 kg ha^{-1} at 3 DAS *fb* hand weeding and earthing at 45 DAS, which increased the seed cotton yield by about 41.5% over the unweeded control.

Phytotoxicity

The treatment application involving pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC at 1650 ml ha^{-1} caused necrosis and stunting below 10% up to 30 days after treatment. Similarly, the same treatment combination at a lower dose of 1000 and 825 ml ha^{-1} also showed necrosis, but it was also below 10%, which subsequently got resolved. The results suggest that while these herbicide treatments initially caused some level of necrosis and stunting in the cotton crops, particularly within the first 30 days post-application, the damage was not severe. This resilience is an important consideration in agricultural practices, indicating that while herbicides can have immediate effects, the plants can often recover if the damage is not too severe. A similar finding was also presented earlier by Hargilas *et al.* (2015) in Rajasthan, where the application of pendimethalin, quizalofop ethyl, and pyrithiobac-sodium cotton crop was not injured; however, foliar injuries were observed by a directed spray of glyphosate.

Economics

The data pertaining to economic analysis is revealed in Table 4. Among all treatments pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC at 650 ml ha^{-1} (EPoE) incurred lower cultivation costs compared to others. Since no control measure was under taken in the weedy check it showed lowest cost of cultivation. Notably, pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC (T_3) at 1000 ml ha^{-1} and 825 ml ha^{-1} exhibited the highest net return of ₹ 92,854 ha^{-1} and ₹ 92,620 ha^{-1}, which was 115% and 114% higher than weedy check, respectively. This may be due to the higher weed control efficiency of these treatments, which subsequently gave positive results for growth parameters, yield attributes and finally net return. Conversely, in the weedy check both gross and net monetary returns were the lowest due to the absence of any control measures leading to the lowest yield. Treatments like pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC at 825 ml ha^{-1} followed by the same treatment at 1000 ml ha^{-1} (EPoE), showed superior B-C ratios, *i.e.*, 1.98 and 1.97, respectively indicating that these treatments provided more favourable returns relative to their costs. In contrast, manual weeding treatments and the weedy check exhibited lower B-C ratios due to the high cost of manual labour involved, suggesting less efficient use of resources compared to herbicidal treatments. Similarly, Satishkumar *et al.* (2023) recorded the maximum mean net return and B-C ratio in cotton + sunflower intercropping system with PE application of pendimethalin at 1.0 kg ha^{-1}+ hand weeding at 40 DAS.

A similar result was also obtained by Veeraputhiran (2023), where higher net income and B-C ratios were associated with pendimethalin PE *fb* weeding by powertiller at 25 and 45 DAS than the control.

SUMMARY

Based on field experimentation, it can be concluded that the treatment application involving pyrithiobac-sodium 7.5% + haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl 1% MEC at 1000 ml ha^{-1} as early post-emergence was the most effective in controlling weeds and enhanced the productivity and profitability of *Bt* cotton in eastern Uttar Pradesh region.

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Table 1. Effect of herbicidal treatments on weed density, weed dry biomass and weed index in cotton.

Treatments	Weed density (no. m^{-2}) at 60 DAA				Weed dry biomass (g m^{-2})	Weed index (WI)
	Monocot	Dicot	Sedges	Total		
Pyrithiobac-sodium 7.5%+ haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl l1% MEC (650ml ha^{-1})	3.33 (10.7)	3.1 (9.3)	13.5 (182.7)	14.24 (203)	10.56 (111)	39.6
Pyrithiobac-sodium 7.5%+ haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl l1% MEC (825ml ha^{-1})	2.92 (8.0)	1.9 (4.0)	12.3 (152.0)	12.81 (164)	9.25 (85.3)	9.9
Pyrithiobac-sodium 7.5%+ haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl l1% MEC (1000 ml ha^{-1})	2.39 (5.3)	1.6 (2.7)	10.6 (113.3)	11.02 (121)	7.82 (60.8)	9.6
Pyrithiobac-sodium10% EC (750ml ha^{-1})	5.03 (25.3)	2.7 (6.7)	12.2 (149.3)	13.48 (181)	11.55 (133)	33.6
Haloxyfop-R-methyl 10.5% w/w EC (1250 ml ha^{-1})	2.12 (4.0)	2.9 (8.0)	13.1 (170.7)	13.52 (183)	10.15 (103)	25.5
Fenoxaprop-p-ethyl 9.3% w/w EC (750 ml ha^{-1})	3.33 (10.7)	3.5 (12.0)	12.8 (164.0)	13.66 (187)	9.63 (92.7)	30.6
Propaquizafop 10%EC (625ml ha^{-1})	4.30 (18.7)	4.5 (20.0)	9.3 (86.7)	11.21 (125)	9.22 (84.5)	21.3
Hand weeding at 30 and 60 DAS	3.54 (12.0)	2.1 (4.0)	7.5 (56.0)	8.51 (72.0)	5.28 (27.5)	33.4
Weed free	0.71 (0.0)	0.7 (0.0)	0.7 (0.0)	0.71 (0.00)	0.71 (0.00)	0.0
Control	7.40 (54.7)	4.9 (24.0)	16.2 (264.0)	18.49 (343)	17.53 (307)	43.5
SEm±	0.25	0.4	0.5	0.42	0.31	-
CD (p=0.05)	0.76	1.1	1.4	1.25	0.91	-

*Figure in parenthesis represents original value, square root transformation of data √x + 0.5, DAA- Days after treatment applications.

Table 2. Effect of herbicidal treatments on weed control efficiency in cotton.

Treatments	Weed control efficiency (%) at 30 DAA					
	Cyperus rotundus	*Cynodon dactylon*	*Echinochloa colonum*	*Parthenium hysterophorus*	*Trianthema portulacastrum*	*Phyllanthus niruri*
Pyrithiobac-sodium 7.5%+ haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl l1% MEC (650ml ha^{-1})	12.56	44.21	54.96	84.44	53.11	8.21
Pyrithiobac-sodium 7.5%+ haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl l1% MEC (825ml ha^{-1})	24.49	45.69	60.53	86.00	71.19	22.56
Pyrithiobac-sodium 7.5%+ haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl l1% MEC (1000 ml ha^{-1})	40.61	75.32	67.41	85.33	73.45	48.21
Pyrithiobac-sodium10% EC (750ml ha^{-1})	37.11	16.16	5.56	92.96	73.16	19.49
Haloxyfop-R-methyl 10.5% w/w EC (1250 ml ha^{-1})	32.94	56.16	100.00	69.26	26.55	4.10
Fenoxaprop-p-ethyl 9.3% w/w EC (750 ml ha^{-1})	16.22	67.59	67.41	69.63	34.46	17.95
Propaquizafop 10%EC (625ml ha^{-1})	48.33	41.67	79.41	59.26	7.12	64.10
Hand weeding at 30 and 60 DAS	77.23	72.36	84.15	59.26	88.70	100.00
Weed free	100.00	100.00	100.00	100.00	100.00	100.00
Control	-	-	-	-	-	-

*Figure in parenthesis represents original value, square root transformation of data $\sqrt{x} + 0.5$, DAA- Days after treatment applications.

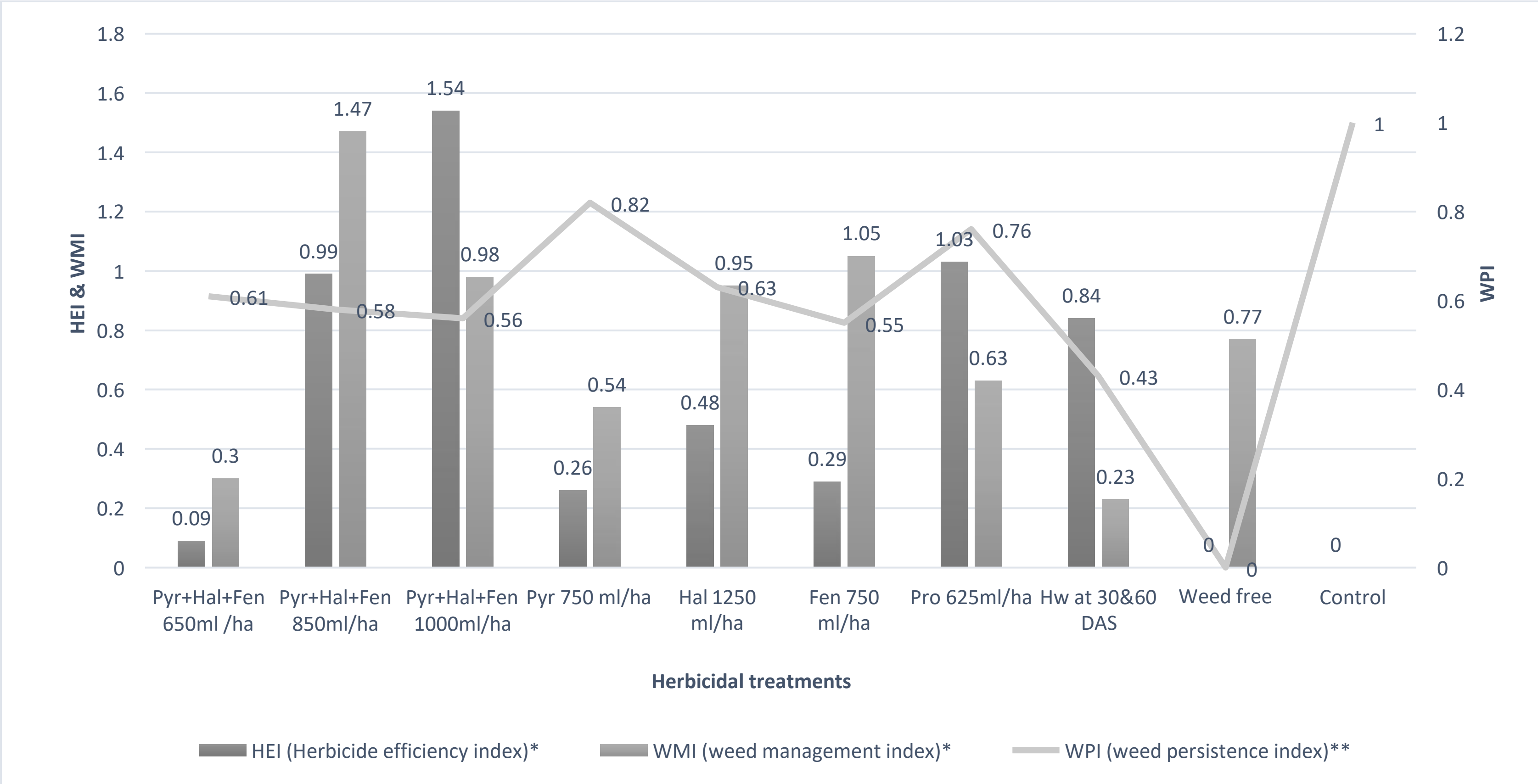

Fig. 1 Herbicide efficiency index, weed management index and weed persistence index due to effect of different herbicidal treatments.

*At 45 days after treatment application, **At 60 days after treatment application;

Pyr- Pyrithiobac- sodium, Hal- Haloxyfop-R-methyl, Fen- Fenoxaprop-p-ethyl, Pro- Propaqiuzafop, DAS- Days after sowing

Table 3. Effect of herbicidal treatments on growth parameters and yield attributes of cotton.

Treatments	Plant height (cm) 90 DAS	No. of Sympodia plant^{-1} 90 DAS	No. of green bolls plant^{-1} 90 DAS	Boll weight (g)	Number of picked bolls plant^{-1}	Seed cotton yield (kg ha^{-1})
Pyrithiobac-sodium 7.5%+ haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl l1% MEC (650ml ha^{-1})	127.67	12.67	9.44	4.39	37.89	1240
Pyrithiobac-sodium 7.5%+ haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl l1% MEC (825ml ha^{-1})	148.33	16.67	12.11	4.47	46.11	1848
Pyrithiobac-sodium 7.5%+ haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl l1% MEC (1000 ml ha^{-1})	159.00	18.33	14.60	4.62	47.49	1855
Pyrithiobac-sodium10% EC (750ml ha^{-1})	131.33	13.00	9.67	4.36	40.22	1363
Haloxyfop-R-methyl 10.5% w/w EC (1250 ml ha^{-1})	137.33	14.00	11.43	4.51	43.10	1528
Fenoxaprop-p-ethyl 9.3% w/w EC (750 ml ha^{-1})	135.33	13.33	11.22	4.47	42.22	1424
Propaquizafop 10%EC (625ml ha^{-1})	156.00	17.00	14.45	4.56	45.45	1614
Hand weeding at 30 and 60 DAS	133.00	12.33	10.56	4.40	42.00	1366
Weed free	152.67	19.33	16.22	4.73	50.56	2052
Control	125.67	11.00	5.78	4.37	26.45	1160
SEm±	5.98	1.01	0.89	0.07	2.12	118
CD (p=0.05)	13.9	2.99	2.66	NS	6.27	350

*DAS- Days after sowing

Table 4. Effect of herbicidal treatments on economics of cotton cultivation.

Treatments	Cost of cultivation (x 10^3 ₹/ ha)			Gross income (x 10^3 ₹/ ha)	Net income (x 10^3 ₹/ ha)	Benefit cost ratio
	Common	Treatment	Total			
Pyrithiobac-sodium 7.5%+ haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl l1% MEC (650ml ha^{-1})	44.86	1.63	46.49	94.05	47.56	1.02
Pyrithiobac-sodium 7.5%+ haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl l1% MEC (825ml ha^{-1})	44.86	1.90	46.77	139.39	92.62	1.98
Pyrithiobac-sodium 7.5%+ haloxyfop-R-methyl 13.5% + fenoxaprop-p-ethyl l1% MEC (1000 ml ha^{-1})	44.86	2.17	47.04	139.89	92.85	1.97
Pyrithiobac-sodium10% EC (750ml ha^{-1})	44.86	3.71	48.58	103.04	54.47	1.12
Haloxyfop-R-methyl 10.5% w/w EC (1250 ml ha^{-1})	44.86	3.36	48.23	115.30	67.07	1.39
Fenoxaprop-p-ethyl 9.3% w/w EC (750 ml ha^{-1})	44.86	2.50	47.36	107.32	59.96	1.27
Propaquizafop 10%EC (625ml ha^{-1})	44.86	1.82	46.68	121.55	74.87	1.60
Hand weeding at 30 and 60 DAS	44.86	12.42	57.28	103.16	45.88	0.80
Weed free	44.86	24.84	69.70	154.27	84.56	1.21
Control	44.86	0.00	44.86	88.13	43.27	0.96

Market price (₹ quintal): Seed cotton = ₹ 70.20 kg^{-1}, Stalk= ₹ 1.5 kg^{-1}