Original Research Article

EFFECT OF NON-CHEMICAL ECO-FRIENDLY WEED MANAGEMENT APPROACHES ON YIELD AND NUTRIENT UPTAKE IN HIGH DENSITY PLANTING COTTON IN *VERTISOL* OF NORTHERN KARNATAKA

Abstract:

Field experiment was conducted in 2017 and 2018 at Department of Agronomy, College of Agriculture, UAS, Raichur with an objective to study the effect of non-chemical eco-friendly weed management approaches on yield, nutrient uptake and balance in soil of high density planting cotton in deep *vertisols*. The experiment was laid out in Randomized Completely Block Design with three replications. There were 14 treatments imposed *viz*., polythene mulch, paddy straw mulch, cotton stalk mulch, intercropping with green manures at 1:1 ratio (Sunnhemp and Cowpea), four different botanicals extracts @ 20% as PE (*Eucalyptus sp.*, *Prosopis juliflora* extract, *Cassia tora and Parthenium hysterophorus*), mechanical, cultural and their combination compared with weed free check, unweeded control and recommended practice. The experiment was carried out in a randomized complete block design replicated thrice. The two years pooled data results registered that, weed free check has recorded significantly greater seed cotton yield (1372 kg ha^{-1}) over rest of the treatments. It was followed by Cotton + Sunnhemp (1:1) subsequently *in-situ* mulching at 45 DAS (1299 kg ha^{-1}), pendimethalin 38.7 CS @ 680 g *a.i.*/ha as PE fb pyrithiobac sodium 10 EC 75 g *a.i.*/ha + quizolofop ethyl 37.5 g *a.i.*/ha at 25 DAS as PoE (1274 kg ha^{-1}) and black polythene sheet mulch (1262 kg ha^{-1}) with lower nutrient upake over weedy check. The eco-friendly treatments *viz*., cotton + Sunnhemp (1:1) and *in-situ* mulching at 45 DAS, mulching with black polythene sheet, Cotton + Cowpea (1:1) and *in-situ* mulching at 45 DAS were at par with weed free check and they might be recommended as these were the best options.

Key words: HDPS (High density planting system), Nutrient uptake and Seed cotton yield

Introduction:

Cotton (*Gossypium sp.*) is popularly known as "the white gold or the king of fibre crops" is an important commercial fibre crop grown under diverse agro-climatic conditions around the world. Karnataka stands eighth in cotton area (5.46 lakh ha) and seventh in production with (18.0 lakh bales) with an average productivity of 560 kg lint ha^{-1} (Anon., 2018). Among different agronomic manipulations that would influence the productivity of cotton, management of weeds is considered to be an important step for achieving higher productivity (Manalil *et al.*, 2017). Weeds primarily compete for nutrients, moisture and sunlight during the early crop growth period than at later stage. Weeds consume 5 to 6 times of nitrogen, 5 to 12 times of phosphorus and 2 to 5 times of potash more than cotton crop at the early growth stages (Mahar *et al.*, 2007) and could be very destractive for cotton production systems. The critical period of weed competition in cotton was found to be 15 to 60 days (Sharma, 2008). Thus, if proper weed control measures are followed, there would be greater availability of nutrients and moisture for the benefit of crop. Manual weed management practice is laborious and expensive. In spite of herbicides being effective in increasing yield, indiscriminate use of herbicides has resulted in serious ecological implications such as development of herbicide resistance weeds and shifts in weed population. Recently, research attention has been focused on to find out alternative strategies for chemical weed control in several crops. Reduction in herbicide use is one of major goals of modern agriculture and there is much emphasis on search for alternative weed management strategies that are cheap, safe and sustainable.

So, the extracts from the different plants which are having less residual effect compared to chemicals used to control the weeds. And farmers look for selective post emergence broad spectrum herbicide /herbicide mixtures. Extracts are considered as an effective, economical and environment friendly/eco-friendly weed management approach. The slow initial growth coupled with indeterminate growth habit favours the growing of intercrops without affecting yield of cotton. Intercropping has unique capacity to raise the unit profitability without disturbing the cotton ecosystem. Intercropping is the growing of two or more crops simultaneously in the alternative rows on the same piece of land in order to utilize available resources efficiently and obtaining more production per unit area (Lithourgidis *et al*., 2011). Two crops differing in rooting ability, nutrient requirements, height and canopy grow simultaneously with least competition (Lithourgidis *et al*., 2006). Weed density and biomass may substantially be reduced through intercropping (Poggio, 2005). Singh *et al.* (2003) indicated that growing companion plants, which are selectively allelopathic to weeds, may provide a cost effective alternative to the use of synthetic chemicals. This study was conducted to study effect of non-chemical eco-friendly weed management approaches on yield, nutrient uptake and balance in soil of high density planting cotton in deep *vertisols*.

MATERIALS AND METHODS

Comment [TD1]: 1. Provide initial soil analysis of the location
2. Map of research location, showing the temperatures and rainfall pattern

Experiment was conducted for two consecutive years 2017-18 and 2018-19 at Department of Agronomy, College of Agriculture, UAS, Raichur. The experiment was laid out in Randomized Completely Block Design with three replications. Fourteen treatments comprised of Mulching with black polythene, Mulching with cotton stalk at 5 t/ha, Mulching with paddy straw at 5 t/ha, Cotton + Sunnhemp (1:1) and *insitu* mulching at 45 DAS, Cotton + Cowpea (1:1) and *insitu* mulching at 45 DAS. Weeding with cycle weeder at 25, 50 and 75 DAS, HW at 25 DAS and IC at 50 and 75 DAS, *Eucalyptus sp.* extract @ 20 % as PE fb IC at 50 and 75 DAS., *Prosopis juliflora* extract @ 20% as PE fb IC at 50 and 75 DAS., *Cassia tora* @ 20% as PE fb IC at 50 and 75 DAS., *Parthenium hysterophorus* extract 20% as PE fb IC at 50 and 75 DAS, pendimethalin 38.7 C S @ 680 g a.i./ha as PE fb pyrithiobac sodium 10EC 75 g *a.i.*/ha + quizolofop ethyl 37.5 g *a.i.*/ha at 25 DAS as PoE, Weed free check and Unweeded control. The recommended dose of fertilizer and spacing for cotton was 80:40:40 NPK kg/ha and 60 cm x 20 cm respectively maintained for all the treatments. Treatments such as polythene sheet mulch, cotton stalk mulch and paddy straw mulch were mulched at the time of sowing, intercropping with sunnhemp and cowpea were grown and in situ mulched at 45 DAS and other herbicide chemicals are used as pre-emergence and post-emergence as per the treatment details. The fresh leaves of botanicals such as, *Eucalyptus sp. Prosopis juliflora, Cassia tora and Parthenium hysterophorus* cut into small species, soaked in alcohol and water @ 1:1 proportion and kept for overnight. After 12 hours, soaked leaves were ground with the help of mixer grinder. From the paste, the leaf extract of each botanical species was prepared by filtration which represented 100 per cent stock solution. From the stock solution, 20 per cent concentration was prepared and sprayed as per the treatment schedule. The weed samples collected for estimation of dry matter production at maturity used for nutrient analysis. The crop samples were ground using Willey mill and used for estimation of N, P and K to work out t uptake of major nutrients.

Nutrient uptake (kg ha^{-1})

Comment [TD2]: Mention all the nutrients to be analyst

Nitrogen content (%) in the plant and weed samples was estimated by the micro Kjeldahl method using Kelplus N analyser after digesting the samples with H_2SO_4 and H_2O_2 (Piper,1966). For phosphorus estimation the tri-acid (HNO_3, $HCLO_4$ and H_2SO_4) in the ratio of (9:3:1) respectively digested plant and weed samples were analyzed by Vanado-molybdo phosphoric acid. The intensity of yellow colour developed was measured by using spectrophotometer at 420 nm (Piper, 1966). Potassium content in the tri-acid was determined with flame photometer (Piper, 1966).

Nutrient uptake = Nitrogen / phosphorus / potassium of plant parts / weeds x weight of seed cotton yield (kg ha^{-1}) / weeds weight

Data analysis

Analysis of variance (ANOVA) for the randomized complete block design was performed to determine the effect of time and rate of application of herbicides on weed species, lit yield and nutrient uptake by weeds and crop. If the ANOVA for the multi-year combined data showed a significant effect between treatments and years, a separate ANOVA was conducted for each individual year by using SAS 9.3 (SAS Inst., Cary, NC, USA 2008) was used for all analyses.

RESULTS AND DISCUSSION

Comment [TD3]: Results for yield not presented

Weed Flora at experimental site

The weed flora observed in both the soils was recorded. In the red soil, among the grasses *Cynodon dactylon*, *Rottboellia exaltata*, *Dactyloctenium aegyptium* and *Dinebraretro flexa* were noticed. *Cyperus rotundus* was the only sedge present in the field. Among the broad leaved weeds, *Parthenium hysterophorus*, *Euphorbia geniculata*, *Trianthema portulaca strum*, *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 *Echinochloa colonum*, *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 argentea* were observed in the field. Weeds compete with the crops for moisture, nutrients, light and CO_2 and there by affect the yield.

Thus the nutrient uptake by crop is an important factor to be determined to know the effect of the control practices.

Nitrogen, phosphorus and potassium nutrient uptake (kg ha^{-1}) by weeds

Nitrogen uptake by weeds

Comment [TD4]: Results not supported by previous studies

A result indicated that weed free check recorded significantly lower over rest of the treatments. Among other treatments, application of pendimethalin 38.7 CS @ 680 g *a.i.* ha^{-1} as PE *fb* pyrithiobac sodium 10 EC @ 75 g *a.i.* ha^{-1} + quizolofop ethyl 5 EC @ 37.5 g *a.i.* ha^{-1} at 25 DAS as POE (4.2 kg ha^{-1}), cotton + sunnhemp (1:1) and then *in situ* mulching at 45 DAS (4.6 kg ha^{-1}), cotton + cowpea (1:1) and then *in situ* mulching at 45 DAS (5.1 kg ha^{-1}), weeding with cycle weeder at 25, 50 and 75 DAS (5.9 kg ha^{-1}) and HW at 25 DAS and IC at 50 and 75 DAS (5.4 kg ha^{-1}) recorded significantly lower nitrogen uptake over unweeded control.

Phosphorus uptake by weeds

Comment [TD5]: Discuss the results

The treatment, weed free check recorded significantly, lower phosphorus removal by weeds (0 kg ha^{-1}) as compared to unweeded control. Application of pendimethalin 38.7 CS @ 680 g *a.i.* ha^{-1} as PE *fb* pyrithiobac sodium 10 EC @ 75 g *a.i.* ha^{-1} + quizolofop ethyl 5 EC @ 37.5 g *a.i.* ha^{-1} at 25 DAS as POE, black polythene sheet mulch, cotton + sunnhemp (1:1) and then *in situ* mulching at 45 DAS, cotton + cowpea (1:1) and *in situ* mulching at 45 DAS, weeding with cycle weeder at 25, 50 and 75 DAS and HW at 25 DAS and IC at 50 and 75 DAS recorded significantly lower phosphorus uptake (0.6, 0.8, 0.7, 0.7, 0.8 and 0.7 kg ha^{-1}, respectively) over unweeded control (2.8 kg ha^{-1}).

Potassium uptake by weeds

Comment [TD6]: Justify result

Potassium uptake by the weeds was as that of nitrogen and phosphorus. Application of pendimethalin 38.7 CS @ 680 g *a.i.* ha^{-1} as PE *fb* pyrithiobac sodium 10 EC @ 75 g *a.i.* ha^{-1} + quizolofop ethyl 5 EC @ 37.5 g *a.i.* ha^{-1} at 25 DAS as POE, black polythene sheet mulching, cotton + sunnhemp (1:1) and *in situ* mulching at 45 DAS, cotton + cowpea (1:1) and then *in situ* mulching at 45 DAS, weeding with cycle weeder at 25, 50 and 75 DAS and HW at 25 DAS and IC at 50 and 75 DAS (5.9, 6.6, 6.2, 6.5, 7.2 and 7.1 kg ha^{-1}, respectively) were on par with each other and superior over unweeded control (20.4 kg ha^{-1}).

Among the weed management practices, the reduction in nutrient removal by weeds was recorded in weed free check and was followed by combined application of pendimethalin 680 g *a.i./* ha^{-1} at early stages of crop growth followed by *fb* pyrithiobac sodium 10 EC @75 g *a.i.* ha^{-1} + quizolofop ethyl 5 EC @ 37.5 g *a.i.* ha^{-1} at 25 DAS as POE. This might be due to fairly weed free condition at early stages of crop growth and the weed free environment created by the PE and POE application of herbicides that reduced dry matter production of weeds. These findings are in line with the reports of Sathishkumar (2016). Among the mulching treatments, black polythene sheet mulch, intercropping and *in situ* mulching of green manures also had lower nutrient removal by weeds compared to unweeded control. The reduced uptake of nutrients by weeds was due to efficient control of predominant grasses, sedges and broad leaved weeds by shade and also by suppressing weeds by reducing competition for natural resources such as light, water, nutrients and applied nutrients for their better growth. This weed free environment helped cotton to exhibit the vigorous growth, subsequently in all the critical stages supported the crop to produce more DMP and suppressed weed in the later stages of crop growth. The removal of weeds during later period by hand weeding has resulted higher WCE and lesser nutrient uptake by weeds. But maximum removal of nutrients by weeds was noticed in unweeded control. Higher uptake of nutrients by weeds under control was due to high weed density and more weed dry weight accumulation corroborating with earlier findings of Malarkodi (2013). The higher nutrient uptake by weeds might be due to the higher weed intensity and biomass in unweeded control treatment and its dominance in utilizing sunlight, moisture and CO_2 over plants resulting in accumulation of more dry matter by weeds and there by absorption of nutrients from soil and reduced nutrient uptake of weeds was due to less weed dry matter in the respective treatments. These results were in close conformity with the findings of Anjum *et al.* (2007) and Veeramani *et al.* (2008) (Table 1).

Nutrient uptake (kg ha^{-1}) by cotton

Nitrogen uptake by cotton

Comment [TD7]: Justify result with previous study

The pooled data indicated that, under weed free check (106.0 kg ha^{-1}), cotton utilized significantly higher uptake of nitrogen over other treatments. While, the other treatments *viz.*, application of herbicides pendimethalin 38.7 CS @ 680 g *a.i.* ha^{-1} as PE *fb* pyrithiobac sodium 10 EC @ 75 g *a.i.* ha^{-1} + quizolofop ethyl 5 EC @ 37.5 g *a.i.* ha^{-1} at 25 DAS as PoE (94.1 kg ha^{-1}), cotton + sunnhemp (1:1) and *in situ* mulching at 45 DAS (93`.9 kg ha^{-1}), cotton + cowpea (1:1) and *in situ* mulching at 45 DAS (90.4 kg ha^{-1}), black polythene sheet mulch (88.8 kg ha^{-1}) and HW at 25 DAS and IC at 50 and 75 DAS (88.3 kg ha^{-1}) were on par with each other but significantly superior over unweeded control.

Phosphorus uptake by cotton

Comment [TD8]: Justify result with previous study

Significantly higher phosphorus uptake by cotton was noticed in weed free check (13.0 kg ha^{-1}) compared to rest of the treatments. This was recorded by the application of pendimethalin 38.7 CS @ 680 g *a.i.* ha^{-1} as PE *fb* pyrithiobac sodium 10 EC @ 75 g *a.i.* ha^{-1} + quizolofop ethyl 5 EC @ 37.5 g *a.i.* ha^{-1} at 25 DAS as PoE (11.4 kg ha^{-1}), cotton + sunnhemp (1:1) and then *in situ* mulching at 45 DAS (10.8 kg ha^{-1}), cotton + cowpea (1:1) and then *in situ* mulching at 45 DAS (10.5 kg ha^{-1}), black polythene mulch and HW at 25 DAS and IC at 50 and 75 DAS (10.4 kg ha^{-1}) and among these, there was no significant difference but were superior over unweeded control (6.5 kg ha^{-1}).

Potassium uptake by cotton

The higher uptake of potassium by cotton was recorded in weed free check (95.3 kg ha^{-1}) over other treatments. Application of pendimethalin 38.7 CS @ 680 g *a.i.* ha^{-1} as PE *fb* pyrithiobac sodium 10 EC @ 75 g *a.i.* ha^{-1} + quizolofop ethyl 5 EC @ 37.5 g *a.i.* ha^{-1} at 25 DAS as POE (84.9 kg ha^{-1}), cotton + sunnhemp (82.1 kg ha^{-1}) and cowpea (1:1) (79.7 kg ha^{-1}) and then *in situ* mulching at 45 DAS black polythene mulch (72.3 kg ha^{-1}) and HW at 25 DAS and IC at 50 and 75 DAS (79.0 kg ha^{-1}) were on par with each other but significantly superior over unweeded control.

Nutrient uptake (N, P and K) by cotton was greatly influenced by weed control treatments as compared to control. Weed free check treatment recorded the highest nutrient uptake as there were no weeds present and there was no competition. Among other treatments, pendimethalin @ 680 g *a.i.* ha^{-1} PE and pyrithiobac sodium @ 75 g *a.i.* ha^{-1} + quizalofop ethyl 37.5 g *a.i.* ha^{-1} (94.1 kg N ha^{-1}, 11.4 kg P ha^{-1} and 84.9 kg N ha^{-1}) was found to be more efficient. Among eco-friendly practices, intercropping and then *in situ* mulching of sunnhemp and cowpea, black polythene mulch also showed higher uptake. The uptake of major nutrients by the crop was function of the crop dry matter production, nutrient availability and nutrient concentration of plants. Hence in these treatments due to minimum weed competition throughout the crop period facilitated higher dry matter production and nutrient uptake by the crop (Nalayini *et al*., 2001). The lower soil N, P and K status was recorded under unweeded control might be due higher weed populations thus reflected more depletion of nutrients by weeds in soil *i.e.* competition for applied nutrients between the weed and crop, which lowers the availability of nutrients to the crop and in turn reduces the growth, yield attributes and yield of the crop. This ultimately resulted in lower uptake. Similar observation was recorded by Madavi (2016) (Table 2).

Seed cotton yield

The pooled data revealed that significantly greater seed cotton yield (1372 kg ha^{-1}) in cotton + sunnhemp (1:1) subsequently *in-situ* mulching at 45 DAS (1299 kg ha^{-1}), pendimethalin 38.7 CS @ 680 g *a.i.*/ha as PE fb pyrithiobac sodium 10 EC 75 g *a.i.*/ha + quizolofop ethyl 37.5 g *a.i.*/ha at 25 DAS as POE (1274 kg ha^{-1}) and black polythene sheet mulch (1262 kg ha^{-1}) and were on par with weed free check. These treatments were on par with each other and superior over unweeded control (917 kg ha^{-1}). Significantly higher yield, growth components in this treatment was mainly attributed to occurrence of less competition between cotton plants and weeds for nutrients which leads more growth and yield attributes (Nalini, 2010). Black polythene mulch controlled the weeds by interrupting the light reaching the weeds and thus reduced the weed intensity and the benefit was witnessed (Nalini, 2007) (Table 3).

Conclusion

The macronutrient contents in cotton crop were higher in weed free check and this was comparable to cotton + sunnhemp (1:1) or cotton + cowpea (1:1) and *in situ* mulching at 45 DAS, were ideal for minimum weed competition facilitated higher DMP and nutrient uptake by the plant in HDPS cotton. Among the leaf extract spray, pre emergence application of *Eucalyptus* extract @ 20 % as PE *fb* IC at 50 and 75 DAS registered significantly lesser weed density, dry weight, nutrient uptake and higher seed cotton yield when compared to control and was on par with other leaf extractants.

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Table 1. Nitrogen, Phosphorus and potassium uptake by weeds as influenced by different non-chemical eco-friendly weed management practices in HDPS cotton

Treatment	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
Mulching with black polythene	4.6	6.2	**5.4**	0.7	0.9	**0.8**	6.2	6.9	**6.6**
Mulching with cotton stalk at 5 t ha^{-1}	8.6	8.8	**8.7**	1.2	1.1	**1.2**	9.3	9.8	**9.6**
Mulching with paddy straw at 5 t ha^{-1}	8.7	8.2	**8.5**	1.1	1.2	**1.2**	8.6	9.4	**9.0**
Cotton + Sunnhemp (1:1) and *in situ* mulching at 45 DAS	3.6	5.5	**4.6**	0.6	0.7	**0.7**	6.0	6.4	**6.2**
Cotton + Cowpea (1:1) and *in situ* mulching at 45 DAS	4.4	5.8	**5.1**	0.7	0.8	**0.7**	6.2	6.7	**6.5**
Weeding with cycle weeder at 25, 50 and 75 DAS	4.6	7.2	**5.9**	0.7	0.8	**0.8**	6.4	8.0	**7.2**
HW at 25 DAS and IC at 50 and 75 DAS	4.4	6.4	**5.4**	0.7	0.8	**0.7**	6.3	7.8	**7.1**
Eucalyptus extract @ 20 % as PE *fb* IC at 50 and 75 DAS.	7.2	9.0	**8.1**	1.2	1.2	**1.2**	9.1	9.2	**9.2**
Prosopis juliflora extract @ 20 % as PE *fb* IC at 50 and 75 DAS.	9.0	10.2	**9.6**	1.3	1.3	**1.3**	9.7	9.5	**9.6**
Cassia tora @ 20 % as PE fb IC at 50 and 75 DAS.	8.8	10.0	**9.4**	1.3	1.3	**1.3**	9.4	9.6	**9.5**
Parthenium extract 20 % as PE *fb* IC at 50 and 75 DAS.	8.9	10.4	**9.7**	1.3	1.3	**1.3**	9.5	9.7	**9.6**
Pendimethalin 38.7 CS @ 680 g *a.i.* ha^{-1} as PE *fb* pyrithiobac sodium 10 EC 75 g *a.i.* ha^{-1} + quizolofop ethyl 5 EC @ 37.5 g *a.i.* ha^{-1} at 25 DAS as PoE.	3.6	4.7	**4.2**	0.6	0.7	**0.6**	5.3	6.5	**5.9**
Weed free check	0.0	0.0	**0.0**	0.0	0.0	**0.0**	0.0	0.0	**0.0**
Unweeded control	18.7	24.2	**21.5**	2.5	3.2	**2.9**	17.8	22.9	**20.4**
S.Em±	**0.5**	**1.0**	**0.6**	**0.1**	**0.1**	**0.1**	**0.4**	**1.0**	**0.6**
C.D. at 5%	**1.3**	**2.9**	**1.7**	**0.2**	**0.2**	**0.3**	**1.2**	**2.8**	**1.6**

Table 2.Nitrogen, phosphorus and potassium uptake by high density planting cotton as as influenced by different non-chemical eco-friendly weed management practices

Treatment	N uptake(kg ha^{-1})			P uptake(kg ha^{-1})			K uptake(kg ha^{-1})		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
Mulching with black polythene	87.0	90.5	**88.8**	10.6	10.4	**10.5**	79.0	79.7	**79.4**
Mulching with cotton stalk at 5 t ha^{-1}	70.2	72.6	**71.4**	9.0	9.0	**9.0**	65.6	65.6	**65.6**
Mulching with paddy straw at 5 t ha^{-1}	82.0	76.7	**79.4**	9.4	9.2	**9.3**	67.4	62.8	**65.1**
Cotton + Sunnhemp (1:1) and *in situ* mulching at 45 DAS	95.8	91.9	**93.9**	10.6	11.0	**10.8**	82.0	82.2	**82.1**
Cotton + Cowpea (1:1) and *in situ* mulching at 45 DAS	92.2	88.6	**90.4**	10.2	10.8	**10.5**	79.4	80.0	**79.7**
Weeding with cycle weeder at 25, 50 and 75 DAS	84.0	85.9	**85.0**	9.7	10.4	**10.1**	76.4	77.2	**76.8**
HW at 25 DAS and IC at 50 and 75 DAS	89.3	87.3	**88.3**	9.9	10.9	**10.4**	76.8	79.2	**79.0**
Eucalyptus extract @ 20 % as PE *fb* IC at 50 and 75 DAS.	75.1	78.6	**76.9**	9.4	9.5	**9.5**	74.0	73.3	**73.7**
Prosopis juliflora extract @ 20 % as PE *fb* IC at 50 and 75 DAS.	75.8	77.8	**76.8**	8.9	9.1	**9.0**	72.7	70.6	**71.7**
Cassia tora @ 20 % as PE fb IC at 50 and 75 DAS.	75.6	75.5	**75.6**	9.0	9.2	**9.1**	72.0	72.0	**72.0**
Parthenium extract 20 % as PE *fb* IC at 50 and 75 DAS.	75.3	75.6	**75.5**	8.7	9.2	**9.0**	72.5	71.2	**71.9**
Pendimethalin 38.7 CS @ 680 g *a.i.* ha^{-1} as PE *fb* pyrithiobac sodium 10 EC 75 g *a.i.* ha^{-1} + quizolofop ethyl 5 EC @ 37.5 g *a.i.* ha^{-1} at 25 DAS as PoE.	91.6	96.6	**94.1**	10.8	11.9	**11.4**	85.2	84.6	**84.9**
Weed free check	106.2	105.7	**106.0**	13.2	12.8	**13.0**	96.8	93.7	**95.3**
Unweeded control	59.9	52.2	**56.1**	6.62	6.4	**6.5**	52.9	50.9	**51.9**
S.Em±	**3.1**	**3.9**	**2.2**	**0.4**	**0.6**	**0.3**	**3.6**	**3.0**	**2.2**
C.D. at 5%	**8.9**	**11.2**	**6.3**	**1.2**	**1.7**	**1.0**	**10.6**	**8.8**	**6.4**

Table 3: Yield in eco-friendly weed management through non-chemical approaches in HDPS cotton

Treatment	2017	2018	Pooled
Mulching with black polythene	1293	1230	**1262**
Mulching with cotton stalk at 5 t ha^{-1}	1072	1063	**1068**
Mulching with paddy straw at 5 t ha^{-1}	1246	1174	**1210**
Cotton + Sunnhemp (1:1) and *in situ* mulching at 45 DAS	1340	1258	**1299**
Cotton + Cowpea (1:1) and *in situ* mulching at 45 DAS	1225	1182	**1204**
Weeding with cycle weeder at 25, 50 and 75 DAS	980	993	**986**
HW at 25 DAS and IC at 50 and 75 DAS	1069	1155	**1112**
Eucalyptus extract @ 20 % as PE *fb* IC at 50 and 75 DAS.	1173	1257	**1215**
Prosopis juliflora extract @ 20 % as PE *fb* IC at 50 and 75 DAS.	1121	1144	**1133**
Cassia tora @ 20 % as PE fb IC at 50 and 75 DAS.	1148	1093	**1120**
Parthenium extract 20 % as PE *fb* IC at 50 and 75 DAS.	1145	1114	**1130**
Pendimethalin 38.7 CS @ 680 g *a.i.* ha^{-1} as PE *fb* pyrithiobac sodium 10 EC 75 g *a.i.* ha^{-1} + quizolofop ethyl 5 EC @ 37.5 g *a.i.* ha^{-1} at 25 DAS as PoE.	1308	1239	**1274**
Weed free check	1467	1277	**1372**
Unweeded control	906	927	**917**
S.Em.±	**55**	**62**	**47**
CD at 5%	**161**	**180**	**137**