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Integrated Weed Management with *Calotropis gigantea* Leaf Extract in Cotton

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Field experiments were conducted during 2012 and 2013, at Agricultural College and Research Institute, Madurai (Tamil Nadu Agricultural University) to study the effect of pre-emergence application of *Calotropis gigantea* leaf extract spray on weed control in cotton. The weed management practices consisted of *Calotropis gigantea* leaf extract spray at three concentrations (10%, 20%, and 30%) chemical weed control (Pendimethlin @ 1.0 kg ha^{-1}), power weeder weeding (PW at twice) and manual weeding (hand weeding twice) in combination. The results revealed that hand weeding twice at 20 and 40 DAS and pendimethalin at 1.0 kg ha^{-1} followed by one hand weeding at 40 DAS resulted in effective control of all the weeds and recorded higher seed cotton yield. Among the leaf extracts spray, pre-emergence application of *Calotropis gigantea* at 30 % concentration followed by hand weeding at 40 DAS recorded lower weed density and dry weight and increased the yield in irrigated cotton compared to lower concentration of *Calotropis gigantea* leaf extracts and un weeded control.

Key words: *Calotropis gigantea,* Leaf extract, Weed density, Dry weight, Yield of cotton

In India, cotton is grown under diverse agro-climatic conditions. Cotton is the most important commercial crop contributing nearly 65 % of total raw material needs of textile industry in our country. India ranks first in global scenario occupying about 33 % of the world cotton area, but with regard to production, it ranks second, next to China. The production increased from 17.6 million bales in 1996-97 to 31.5 million bales during 2007-08. During 2013, around 30 million bales is projected, thereby it is clearly indicated that through newer technologies and innovative approaches sustainability in production could be achieved.

Cotton being a long duration and wide spaced crop having the habit of growing at slower rate in early stages much of vacant interspaces remain unutilized. Hence, weeds take the advantage of soil moisture, soil fertility and environmental conditions to suppress the cotton growth. The major constraints in cotton production are pests and weeds. Weed competition is severe during its initial growth stages. The increasing cost and unavailability of labour in time has forced to use herbicides for weed control in cotton. Hence, there is a need for selection of pre-emergence herbicides to control early emerging weeds during initial crop growth period. Several herbicides are used in cotton. Indiscriminate use of herbicides has resulted in serious ecological implications such as resistance and shifts in weed population, minor weeds becoming dominant, greater environmental pollution and health hazards. Recently, research attention is focused to find out alternative strategies for chemical weed control in crops.

Allelochemicals present in the plant species may be used to develop newer bioherbicide to combat the evolution of herbicide resistance in weeds and by reducing the chemical usage in weed control. More over, allelopathic crops may be used in different ways to influence weeds such as, surface mulch, incorporation into the soil, spraying of leaf extracts, crop rotation, smothering or mixed cropping and intercropping.

The use of allelopathic plant extracts is economical and eco friendly, but the reduction in weed biomass is less than herbicides and manual weeding (Abdul Khaliq *et al.,* 2012). Allelopathic plant, *Calotropis gigantea* contains several chemicals such as *Calotropone, Gofruside* (Zhu-Nian Wang *et al.,* 2008) and its latex contains the cardiac glycosides, calotopin, uscharin, calotoxin, calactin and uscharidin and gigantin (Narendra Nalwaya, 2009). Allelopathic activity is not attributed to the effect of a single compound, but it is the result of combination and interaction of many allelochemicals in plant species. Oudhia *et al.* (1999) reported that the extracts of leaf and stem of *Calotropis gigantea* affected germination and seedling vigour of agricultural crops. Effect of *Calotropis gigantea* on weeds has not been well studied. Traditionally in Tamil Nadu, *Calotropis* spp. is incorporated in field. Based on this concept, the present study was carried out to evaluate the efficacy of *Calotropis gigantea* for weed control in cotton compared with herbicides and mechanical and physical weed control.

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Materials and Methods

Field experiments were conducted at Agricultural College and Research Institute, Madurai during 2012 and 2013. Field trials were laid out in randomized block design with fourteen treatments replicated thrice. The weed management practices evaluated in the present study consisted of *Calotropis gigantea* leaf extract spray at three concentrations (10%, 20%, and 30%) chemical weed control (Pendimethlin @ 1.0 kg ha^{-1}) power weeder weeding (PW twice) and manual weeding (hand weeding twice) in combination. The various weed management practices *viz*., PE Calotropis 30% + one hand weeding (T_1), PE Calotropis 30% + one power weeding (T_2), PE Calotropis 30% + EPoE of Calotropis 30% (T_3), PE Calotropis 20% + one hand weeding (T_4), PE Calotropis 20% + one power weeding (T_5), PE Calotropis 20% + EPoE of Calotropis 20% (T_6), PE Calotropis 10% + one hand weeding (T_7), PE Calotropis 10% + one power weeding (T_8), PE Calotropis 10% + EPoE of Calotropis 10% (T_9), PE Pendimethalin @1.0 kg ha^{-1} + one hand weeding (T_{10}), PE Pendimethalin @ 1.0 kg ha^{-1} + one power weeding (T_{11}), Two hand weeding at 20 and 40 DAS (T_{12}), Two power weeding at 20 and 40 DAS (T_{13}) were tested and compared with unweeded control (T_{14}).

Method of leaf extracts preparation

The fresh leaves of *Calotropis gigantea* were collected, cut into small pieces and soaked in alcohol @ 1:1 proportion and kept for overnight. After 12 hrs, soaked leaves were ground with the help of mixer grinder. From the paste, the leaf extract was prepared by filtration, which served as100 per cent stock solutions. From the stock solution, 10 per cent, 20 per cent and 30 per cent concentration were prepared and sprayed on 3 DAS (PE) and 10 DAS (EPoE) by using hand sprayer. In this experiment SVPR 4 variety was used and the NPK recommendation adopted was @ 80:40:40 kg ha^{-1}.

Results and Discussion

Effect on weeds

Weed flora of the experimental field consisted of fourteen types, and among these weeds, *Cyanodon dactylon* and *Echinochloa colonum* were the dominant grass; *Cyperus rotundus* was the only sedge; T*rianthema portulacastrum, Corchorus trilocularis* and *Cleome viscosa* were the predominant broad leaved weeds. The results of the experiment revealed that the broad leaved weeds dominated over grasses and sedges in cotton during the initial growth stage. Among broad leaved weeds, *Trianthema portulacastrum* was the

Table1. Effect of different weed management practices on the density of weeds in cotton

Treatments		Weed density at 60 DAS (No. m^{-2})					
		2012			2013		
		Grass	Sedge	BLW	Grass	Sedge	BLW
T_1 - PE *Calotropis* leaf extract @ 30 % + HW on 40 DAS		11.92	7.85	24.95	8.17	6.47	12.59
		(3.52)	(2.89)	(5.04)	(2.94)	(2.64)	(3.62)
T_2 - PE *Calotropis* leaf extract @ 30 % + PWW on 40 DAS		12.28	8.08	26.54	8.66	6.74	13.99
		(3.57)	(2.93)	(5.20)	(3.03)	(2.69)	(3.81)
T_3 - PE *Calotropis* leaf extract @ 30 % + EPoE *Calotropis* leaf extract @	30 %	29.89	12.24	67.64	26.81	11.54	43.99
		(5.51)	(3.57)	(8.25)	(5.23)	(3.47)	(6.67)
T_4 - PE *Calotropis* leaf extract @ 20 % + HW on 40 DAS		12.71	8.32	33.41	9.04	6.95	22.34
		(3.63)	(2.97)	(5.82)	(3.09)	(2.73)	(4.78)
T_5 - PE *Calotropis* leaf extract @ 20 % + PWW on 40 DAS		13.19	8.80	34.93	9.37	7.12	23.70
		(3.70)	(3.05)	(5.95)	(3.14)	(2.76)	(4.92)
T_6 - PE *Calotropis* leaf extract @ 20 % + EPoE *Calotropis* leaf extract @	20 %	30.76	12.53	70.55	28.10	11.82	46.06
		(5.59)	(3.61)	(8.43)	(5.35)	(3.51)	(6.82)
T_7 - PE *Calotropis* leaf extract @ 10 % + HW on 40 DAS		13.74	8.86	44.57	9.47	7.28	30.06
		(3.77)	(3.06)	(6.71)	(3.16)	(2.79)	(5.53)
T_8 - PE *Calotropis* leaf extract @ 10 % + PWW on 40 DAS		14.31	9.05	46.33	9.84	7.45	31.15
		(3.85)	(3.09)	(6.84)	(3.21)	(2.82)	(5.63)
T_9 - PE *Calotropis* leaf extract @ 10 % + EPoE *Calotropis* leaf extract @	10 %	32.25	12.90	75.30	29.13	12.39	48.68
		(5.72)	(3.66)	(8.71)	(5.44)	(3.59)	(7.01)
T_{10} - Pendi. @ 1.0 kg ha^{-1} + HW on 40 DAS		3.11	0.82	14.11	2.01	0.69	4.45
		(1.90)	(1.15)	(3.76)	(1.59)	(1.09)	(2.23)
T_{11} - Pendi. @ 1.0 kg ha^{-1} + PWW on 40 DAS		3.57	0.92	14.61	2.09	0.73	4.84
		(2.02)	(1.19)	(3.82)	(1.61)	(1.11)	(2.31)
T_{12} - HW on 20 and 40 DAS		2.96	0.78	13.98	1.88	0.62	4.31
		(1.86)	(1.13)	(3.74)	(1.54)	(1.06)	(2.19)
T_{13} - PWW on 20 and 40 DAS		4.12	1.06	16.17	2.40	0.85	5.54
		(2.15)	(1.25)	(4.02)	(1.70)	(1.16)	(2.46)
T_{14} - Unweeded control		33.57	13.86	86.73	29.99	12.75	56.26
		(5.84)	(3.79)	(9.34)	(5.52)	(3.64)	(7.53)
S. Ed		0.17	0.115	0.295	0.16	0.105	0.215
CD (P = 0.05)		0.34	0.23	0.59	0.32	0.21	0.43

Data subjected to $\sqrt{(X+0.5)}$) transformation values, figures in the parenthesis are transformed values

dominant weed flora during both the years. Dominance of broad leaved weeds in early stages was due to their faster growth and deep root system and promoted the absorption of soil moisture as reported by Kumar (2004).

All the weed control methods reduced the density of three types of weeds at 60 DAS as compared to unweeded control in both seasons (Table 1). Hand weeding twice at 20 and 40 DAS and pendimethalin at 1.0 kg ha^{-1} followed by one hand weeding at 40 DAS resulted in effective control of all the weeds. Hand weeding twice at 20 and 40 DAS recorded with reduced grass weed density (2.96 m^{-2}; 1.88 m^{-2}), grass dry weight (9.68 kg ha^{-1}; 6.74 kg ha^{-1}) and broad leaved weed density (13.98 m^{-2}; 4.31 m^{-2}) and dry weight (26.64 kg ha^{-1}; 9.55 kg ha^{-1}) with higher weed control efficiency in both seasons. Application of pendimethalin at 1.0 kg ha^{-1} followed by one hand weeding controlled grass (3.11 m^{-2}; 2.01 m^{-2}) and broad leaved weed (14.11 m^{-2} ; 4.45 m^{-2}) than sedge. Srinivasan (2003) reported that hand weeding twice registered the lowest dry weight of grass and broad leaved weeds and was on par with chemical weed control in cotton. Pendimethalin resulted in effective control of broad leaved weeds, grass and to some extent on sedge due to its broad spectrum action. In grass, it enters through the coleoptile and shoots of the seedling below the ground and effectively control the weeds. The left over weeds were controlled by manual weeding at 40 DAS. Pre emergence application of pendimethalin recorded lesser weed population when compared to other weed control methods as reported earlier by Nalini *et al.* (2011).

Table 2. Effect of different weed management practices on the dry weight of weeds in cotton

Treatments	Weed dry weight at 60 DAS (kg ha^{-1})					
	2012			2013		
	Grass	Sedges	BLW	Grass	Sedge	BLW
T_1 - PE *Calotropis* leaf extract @ 30 % + HW on 40 DAS	33.26	18.95	45.88	30.19	11.96	34.19
	(5.81)	(4.41)	(6.81)	(5.54)	(3.53)	(5.89)
T_2 - PE *Calotropis* leaf extract @ 30 % + PWW on 40 DAS	33.49	18.95	46.97	30.41	11.96	34.78
	(5.83)	(4.41)	(6.89)	(5.56)	(3.53)	(5.94)
T_3 - PE *Calotropis* leaf extract @ 30 % + EPoE *Calotropis* leaf extract @ 30 %	44.26	41.62	239.44	39.70	29.42	188.84
	(6.69)	(6.49)	(15.49)	(6.34)	(5.47)	(13.76)
T_4 - PE *Calotropis* leaf extract @ 20 % + HW on 40 DAS	34.78	19.12	48.08	31.20	11.96	36.83
	(5.94)	(4.43)	(6.97)	(5.63)	(3.53)	(6.11)
T_5 - PE *Calotropis* leaf extract @ 20 % + PWW on 40 DAS	35.02	19.12	50.05	31.20	11.96	37.45
	(5.96)	(4.43)	(7.11)	(5.63)	(3.53)	(6.16)
T_6 - PE *Calotropis* leaf extract @ 20 % + EPoE *Calotropis* leaf extract @ 20 %	44.93	42.01	241.92	40.72	29.97	190.22
	(6.740	(6.52)	(15.57)	(6.42)	(5.52)	(13.81)
T_7 - PE *Calotropis* leaf extract @ 10 % + HW on 40 DAS	35.62	19.48	55.45	31.65	12.17	39.44
	(6.01)	(4.47)	(7.48)	(5.67)	(3.56)	(6.32)
T_8 - PE *Calotropis* leaf extract @ 10 % + PWW on 40 DAS	36.10	19.48	56.65	31.76	12.17	40.59
	(6.05)	(4.47)	(7.56)	(5.68)	(3.56)	(6.41)
T_9 - PE *Calotropis* leaf extract @ 10 % + EPoE *Calotropis* leaf extract @ 10 %	45.88	42.53	244.42	41.88	30.52	194.38
	(6.81)	(6.56)	(15.65)	(6.51)	(5.57)	(13.96)
T_{10} - Pendi. @ 1.0 kg ha^{-1} + HW on 40 DAS	10.13	6.42	27.27	7.06	2.81	9.87
	(3.26)	(2.63)	(5.27)	(2.75)	(1.82)	(3.22)
T_{11} - Pendi. @ 1.0 kg ha^{-1} + PWW on 40 DAS	10.32	6.42	28.02	7.23	2.92	10.19
	(3.29)	(2.63)	(5.34)	(2.78)	(1.85)	(3.27)
T_{12} - HW on 20 and 40 DAS	9.68	6.31	26.64	6.74	2.67	9.55
	(3.19)	(2.61)	(5.21)	(2.69)	(1.78)	(3.17)
T_{13} - PWW on 20 and 40 DAS	10.66	6.47	28.88	7.57	3.00	10.66
	(3.34)	(2.64)	(5.42)	(2.84)	(1.87)	(3.34)
T_{14} - Unweeded control	50.19	43.19	269.45	43.32	31.20	210.33
	(7.12)	(6.61)	(16.43)	(6.62)	(5.63)	(14.52)
S. Ed	0.23	0.21	0.97	0.21	0.17	0.39
CD (P = 0.05)	0.46	0.42	0.485	0.42	0.33	0.79

Data subjected to $\sqrt{(X+0.5)}$ transformation values, figures in the parenthesis are transformed values

Un weeded control recorded higher weed density of grass (33.57 m^{-2}; 29.99 m^{-2}), sedge (13.86 m^{-2}; 12.75 m^{-2}) and broad leaved weeds (86.73 m^{-2}; 56.26 m^{-2}) in both the years as compared to other treatments.

The dry weight of grasses, sedges and broadleaved weeds were reduced due to different weed management practices (Table 2). Regarding the weed control efficiency, hand weeding twice at 20 and 40 DAS and pendimethalin at 1.0 kg ha^{-1} followed by one hand weeding at 40 DAS registered higher WCE in BLW ranging between 89.88 and 95.46 per cent. The integrated weed management practice gave the broad spectrum weed control and higher WCE as a result of longer persistency in the soil profile (Table 3). Unweeded check resulted in reduced WCE at 60 DAS of crop growth.

Among the leaf extracts spray, pre emergence

application of *Calotropis gigantea* at 30% with one hand weeding at 40 DAS resulted in reduced weed density and weed dry weight and higher weed control efficiency as compared to *Calotropis gigantea* at 20% and 10 % with one hand weeding at 40 DAS (Table 2). Ghasemi *et al.* (2012) reported that *Calotropis procera* dry leaf water extracts had the allelopathic properties of germination inhibition, plumule and radicle growth reduction in cucumber, brinjal and tomato at higher (60%) concentrations. Cheema (2000) reported that density and dry weight of weeds were inhibited by several phytotoxins present in sorghum water extracts.

Table 3. Effect of different weed management practices on weed control efficiency in cotton

Treatments	Weed control efficiency at 60 DAS (%)					
	2012			2013		
	Grass	Sedges	BLW	Grass	Sedge	BLW
T_1 - PE *Calotropis* leaf extract @ 30 % + HW on 40 DAS	33.75	56.13	82.97	30.31	61.66	83.74
T_2 - PE *Calotropis* leaf extract @ 30 % + PWW on 40 DAS	33.28	56.13	82.57	29.80	61.66	83.46
T_3 - PE *Calotropis* leaf extract @ 30 % + EPoE *Calotropis* leaf extract @ 30 %	11.83	3.64	11.14	8.38	5.69	10.22
T_4 - PE *Calotropis* leaf extract @ 20 % + HW on 40 DAS	30.70	55.72	82.16	27.99	61.66	82.49
T_5 - PE *Calotropis* leaf extract @ 20 % + PWW on 40 DAS	30.23	55.72	81.42	27.99	61.66	82.20
T_6 - PE *Calotropis* leaf extract @ 20 % + EPoE *Calotropis* leaf extract @ 20 %	10.49	2.74	10.21	6.02	3.93	9.56
T_7 - PE *Calotropis* leaf extract @ 10 % + HW on 40 DAS	29.04	54.90	79.42	26.95	60.98	81.25
T_8 - PE *Calotropis* leaf extract @ 10 % + PWW on 40 DAS	28.07	54.90	78.97	26.69	60.98	80.70
T_9 - PE *Calotropis* leaf extract @ 10 % + EPoE *Calotropis* @ 10 %	8.60	1.52	9.40	3.33	2.15	7.58
T_{10} - Pendi. @ 1.0 kg ha^{-1} + HW on 40 DAS	79.82	85.14	89.88	83.70	90.99	95.31
T_{11} - Pendi. @ 1.0 kg ha^{-1} + PWW on 40 DAS	79.43	85.14	89.60	83.32	90.63	95.15
T_{12} - HW on 20 and 40 DAS	80.72	85.39	90.11	84.45	91.45	95.46
T_{13} -PWW on 20 and 40 DAS	78.77	85.02	89.28	82.54	90.39	94.93
T_{14} - Unweeded control	0.00	0.00	0.00	0.00	0.00	0.00

Effect on yield attributes and seed cotton yield

Hand weeding twice recorded higher seed cotton yield of 2185 and 2293 kg ha^{-1}, and other yield attributes during 2012 and 2013, over unweeded control (Table 4). This might be due to season long weed control, which might have been favourable for better growth and enhanced leaf area contributing increased photosynthesis and translocation of more photosynthates to sink recording increased boll weight and seed cotton yield (Nalini *et al.,* 2011). The next best treatment was the pendimethalin at 1.0 kg ha^{-1}+ hand weeding at 40 DAS.

Among the leaf extracts sprayed, *Calotropis gigantea* at 30% concentration with hand weeding at 40 DAS resulted in higher seed cotton yield (1884 and 1980 kg ha^{-1})in both years. It might be due to the growth promoting effect of *Calotropis gigantea* extracts that would have assisted in better growth and increased seed cotton yield as suggested by Sripunitha, (2009).

Table 4. Effects of weed management practices on yield attributes and yield of cotton

Treatment	Seed cotton yield and yield attributes					
	2012			2013		
	Bolls $plant^{-1}$ (Nos.)	Boll weight (g $boll^{-1}$)	Seed cotton yield (kg ha^{-1})	Bolls $plant^{-1}$ (Nos.)	Boll weight (g $boll^{-1}$)	Seed cotton yield (kg ha^{-1})
T_1 - PE *Calotropis* leaf extract @ 30 % + HW on 40 DAS	21.61	3.68	1884	20.12	3.70	2010
T_2 - PE *Calotropis* leaf extract @ 30 % + PWW on 40 DAS	21.33	3.68	1850	20.01	3.69	1998
T_3 - PE *Calotropis* leaf extract @ 30 % + EPoE *Calotropis* leaf extract @30 %	12.01	3.16	1408	14.21	3.00	1582
T_4 - PE *Calotropis* leaf extract @ 20 % + HW on 40 DAS	18.96	3.56	1638	17.43	3.67	1823
T_5 - PE *Calotropis* leaf extract @ 20 % + PWW on 40 DAS	18.89	3.56	1603	17.13	3.67	1811
T_6 - PE *Calotropis* leaf extract @ 20 % + EPoE *Calotropis* leaf extract @ 20 %	11.95	3.09	1385	13.55	3.00	1560
T_7 - PE *Calotropis* leaf extract @ 10 % + HW on 40 DAS	18.62	3.47	1589	16.75	3.65	1782
T_8 - PE *Calotropis* leaf extract @ 10 % + PWW on 40 DAS	18.56	3.47	1572	19.64	3.63	1759
T_9 - PE *Calotropis* leaf extract @ 10 % + EPoE *Calotropis* leaf extract @ 10 %	11.78	2.96	1374	12.99	2.98	1541
T_{10} - Pendi. @ 1.0 kg ha^{-1} + HW on 40 DAS	23.42	3.71	2123	26.18	3.86	2232
T_{11} - Pendi. @ 1.0 kg ha^{-1} + PWW on 40 DAS	23.18	3.71	2087	25.82	3.81	2196
T_{12} - HW on 20 and 40 DAS	24.50	3.72	2185	26.30	3.91	2293
T_{13} - PWW on 20 and 40 DAS	22.92	3.69	2045	24.76	3.75	2174
T_{14} - Unweeded control	11.60	2.87	1356	12.90	2.96	1517
S. Ed	0.82	0.15	80	0.88	0.16	86
CD (P = 0.05)	1.63	0.30	159	1.77	0.31	172

Cotton being a wide spaced and slow growing crop is sensitive to weed competition at early stages of growth than at later stages. Weeds compete with crop for light, nutrients and water. This would have resulted in poor seed cotton yield under unweeded control (1356 kg ha^{-1}; 1517 kg ha^{-1}) in both seasons. Nalini *et al.*, (2011) also reported similarly.

Conclusion

From the study, it could be concluded that two hand weeding at 20 and 40 DAS (T_{12}), pre emergence application of pendimethalin at 1.0 kg ha^{-1} + HW (T_{10}), would result in effective control of all the weeds increasing seed cotton yield. Among the leaf extracts, pre emergence spray of *Calotropis gigantea* extract @ 30 % + HW (T_1) and pre emergence spray of *Calotropis gigantea* extract @ 30 % + PW (T_2) were found to reduce weed density, weed dry weight resulting in increased seed cotton yield.

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