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RESEARCH ARTICLE

Productivity and economics of cotton under different weed management practices and intercropping systems

A. Sathishkumar*[1], E. Subramanian[2], G. Selvarani[3] and P. Rajesh[4]

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ABSTRACT

Field experiments were conducted during summer 2016 and winter 2016 -17 at Agricultural College and Research Institute, Madurai, Tamil Nadu, India to study the effect of intercropping systems and weed management practices on productivity and economics of irrigated cotton. The results indicated that, sole cotton and cotton + sesame intercropping system in 1:1 row proportion resulted in significantly higher seed cotton yield (SCY) of 1.43, 1.38 t/ha and 1.61, 1.56 t/ha, during summer 2016 and winter 2016-17, respectively and it was followed by cotton + sunflower intercropping system in 1:1 row proportion. The lower SCY was obtained with cotton + sorghum intercropping system in 1:1 row proportion. Among the different weed management practices, hand weeding twice at 20 and 40 DAS recorded significantly higher seed cotton yield. It was followed by pre-emergence (PE) application of pendimethalin at 1.0 kg/ha + hand weeding at 40 DAS. Considering the overall economics of the system, the maximum mean net return of ₹ 48822/ha and B: C ratio of 1.97 were recorded in cotton + sunflower intercropping system with PE application of pendimethalin at 1.0 kg/ha + hand weeding at 40 DAS. This was closely followed by cotton + sesame intercropping system with PE application of pendimethalin at 1.0 kg/ha + hand weeding at 40 DAS. Intercropping of sunflower and sesame in cotton with 1:1 row proportion found remunerative over sole cotton.

Keywords: Allelopathy**,** Economics, Leaf extracts**,** Intercropping, Productivity, Sesame, Sunflower, Seed cotton yield, Weed management

INTRODUCTION

Cotton the "*white gold or the king of fibres*" is one of the most important commercial crops in India. The initial slow growth and adoption of wider spacing favours the weeds to grow luxuriously in cotton fields (Javaid and Anjum 2006). Weeds, besides removing moisture and nutrients, harbour insects and diseases. Poor crop stands due to weed competition has been found to lower production by 30-90% depending upon weed pressure (Samunder 2014). Manual weed management practices are laborious and expensive (Hozayn *et al*. 2011). Despite herbicides being effective in increasing yield, indiscriminate use of herbicides has resulted in serious ecological implications such as development of herbicide resistance weeds and shift in weed population. Recently, research attention has been focused to find out alternative strategies for chemical weed control in several crops. Allelopathy is considered as an effective, economical and environment friendly weed management approach (Iqbal and Cheema 2009). 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. The allelopathic crops can be used as intercrops, mulches or water extracts (Fujii 2003). The slow initial growth coupled with indeterminate growth habit favours the growing of intercrops without affecting yield of cotton. 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). Intercropping has unique capacity to raise the unit profitability without disturbing the cotton ecosystem. The present study was conducted to find out a suitable

[1] Tamil Nadu Agricultural University, Agricultural College and Research Institute, Madurai, Tamil Nadu 625104, India

[2] TNAU, Krishi Vigyan Kendra, Madurai, Tamil Nadu 625104, India

[3] TNAU, Department of Agricultural Extension and Rural Sociology, AC&RI, Madurai, Tamil Nadu 625104, India

[4] Department of Crop Management, RVSAC, Thanjavur, Tamil Nadu 613402, India

* Corresponding author email: sathishkumar08668@gmail.com

intercropping and weed management options without affecting the productivity of cotton.

MATERIALS AND METHODS

Field experiments were conducted at Agricultural College and Research Institute, Madurai during summer 2016 and winter 2016-17. Twenty four treatment combinations comprised of four intercropping, cotton + sorghum (1:1), cotton + sunflower (1:1), cotton + sesame (1:1), sole cotton and six weed management practices, *viz*. pre-emergence (PE) *Prosopis juliflora* leaf extract 30% + one hand weeding at 40 DAS, PE *Annona squamosa* leaf extract 30% + one hand weeding at 40 DAS, PE *Mangifera indica* leaf extract 30% + one hand weeding at 40 DAS, PE pendimethalin 1.0 kg/ ha+ one hand weeding on 40 DAS, two hand weeding at 20 and 40 DAS, control (no weeding or spray). The experiment was laid out in split-plot design with three replications. The soil of the experimental field was well drained and sandy clay loam in texture. The soil was neutral in reaction and low in available nitrogen, medium in available phosphorus and available potassium. Healthy and viable seeds of '*SVPR 4'* cotton variety was sown as base crop at the rate of 15 kg/ha. Main cotton crop was sown with row to row spacing of 75 cm and plant to plant spacing of 30 cm, on the same day intercrops, *viz*. sorghum (*CO 30*), sunflower (*COSFV 5*), sesame (*SVPR 1*) was sown in between two rows of cotton crop following 1:1 ratio for main and intercrops. The plant to plant spacing adopted for intercrop was 30 cm. The recommended dose of NPK (80:40:40 kg NPK/ha) were applied to cotton crop in the form of urea, phosphorus and potassium. Entire dose of phosphorus, 50% of N and K were applied to cotton as basal placement by the side of seed line. The remaining 50% of recommended dose of nitrogen and potassium was top dressed on 45 DAS by placement method. The fertilizers were placed 5 cm away from seed row and covered with soil. Based on the plant populations of intercrops, *viz*. sorghum, sunflower and sesame were applied with 100% recommended dose of fertilizer 90:45:45, 60:30:30 and 35:23:23 kg of NPK/ha in the form of urea, P and K, respectively. Leaves of *Prosopis juliflora, Annona squamosa* and *Mangifera indica* species at vegetative stage were collected and washed gently with tap water for few seconds for removing contaminants like dust *etc*. The fresh leaves of above species were cut into small pieces, soaked in alcohol and water in 1:1 proportion and kept for overnight. After 12 hours, soaked leaves were grounded 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 (Sripunitha 2009). From the stock solution, 30 per cent concentration was prepared and sprayed on 3 DAS by using knapsack sprayer as per the treatment schedule. The data were statistically analysed following the procedure given by Gomez and Gomez (1984) for split plot design. Weed control efficiency (WCE), weed control smothering efficiency (WSE) and weed index (WI) were worked out using formulae suggested by Mani *et al*. (1973) and by Gil and Vijayakumar (1969).

RESULTS AND DISCUSSION

Weed control efficiency (%)

Among the weed management practices, higher WCE was recorded in PE application of pendimethalin at 1.0 kg/ha with 74.5% at 20 DAS during both the years (**Table 1**). The hand weeding twice at 20 and 40 DAS registered higher WCE (84.0 and 94.6% at 40 and 60 DAS, respectively) during both the seasons. This might be due to lesser weed competition by the hand weeding which favoured the growth and development of cotton, thereby higher weed control efficiency was obtained during later stages of crop growth than other weed management practices (Nithya and Chinnusamy 2013). Lower WCE (24.6, 20.0 and 21.1 at 20, 40 and at 60 DAS, respectively) was recorded under control.

Weed smothering efficiency (%)

Intercropping and weed management treatments appreciably influenced the weed smothering efficiency (**Table 2**). Cotton + sorghum intercropping system registered higher WSE with 45.5, 52.4 and 76.0% at 20, 40 and at 60 DAS, during both the seasons, respectively. This was followed by cotton + sesame intercropping system. This is only because the lower availability of space and light led to lower density of weeds and ultimately recorded lower weed dry weight in intercropping and suppressed the weed species by more canopy cover. These findings were in conformity with those reported by Haque *et al*. (2008) and Tripathi *et al.* (2008).

Weed index

Weed index (WI) is a measure of yield loss caused due to varying degree of weed competition compared to the relatively weed free condition throughout the crop period leading to higher productivity (**Table 3**). Sole cotton registered the lower weed index with the value of 26.6 and 25.9% during summer 2016 and winter 2016-17. Among the intercropping system, cotton + sesame recorded minimum weed index of 29.1 and 28.8% during both

the years. Among the weed management practices, hand weeding twice at 20 and 40 DAS registered lower weed index of 15.0 and 15.1% during both the seasons. This might be due to effective weed control achieved by above treatments in terms of reduced density and biomass of weeds. The maximum weed index of 69.1 and 72.0% cent was recorded under control during summer 2016 and winter 2016-17. This might be due to reduction of seed cotton yield under increased pressure of weed competition for space, light, nutrients *etc*. Similar results were also reported by Sarkar (2006).

Number of sympodia

Perceptible difference in the number of sympodia/plant was observed with intercropping system and weed management practices (**Table 4**). Sole cotton produced the greater number of sympodia/plant in cotton. This was followed by cotton + sesame and cotton + sunflower intercropping systems during summer 2016 and winter 2016-17. The increase in sympodia under sole cotton might be attributed to the increased plant height resulting in production of more nodal points /

Table 1. Intercropping system and weed management practices on weed control efficiency (%) in cotton during summer 2016 and winter 2016-17

Treatment	20 DAS					40 DAS					60 DAS				
	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean
PE *Prosopis juliflora* leaf extract 30% + one HW on 40 DAS	68.8	66.9	68.1	54.7	64.6	65.6	56.7	62.7	46.8	58.0	85.9	84.2	84.8	78.7	83.4
PE *Annona squamosa* leaf extract 30% + one HW on 40 DAS	62.5	60.6	61.1	49.9	58.5	55.7	50.8	53.8	42.5	50.7	82.4	81.1	81.8	76.2	80.4
PE *Mangifera indica* leaf extract 30% + one HW on 40 DAS	78.5	73.7	74.6	71.0	74.5	74.0	70.2	71.8	68.0	71.0	88.7	87.4	87.9	86.4	87.6
PE Pendimethalin 1.0 kg/ha + one HW on 40 DAS	87.0	82.4	84.8	80.8	83.8	82.6	77.5	80.6	75.9	79.2	92.3	89.8	91.2	89.4	90.7
Two HW at 20 and 40 DAS	41.9	38.1	40.7	6.5	31.8	89.2	86.1	87.5	84.0	86.7	95.7	94.3	94.8	93.5	94.6
Control (no weeding or spray)	35.4	29.7	33.2	-	24.6	35.0	18.3	26.5	-	20.0	33.4	23.2	27.6	-	21.1
Mean	62.3	58.5	60.4	43.8		67.0	59.9	63.8	52.8		79.7	76.7	78.0	70.7	

I_1- Cotton + Sorghum (1:1), I_2 - Cotton + Sunflower (1:1), I_3 - Cotton + Sesame (1:1), I_4- Sole cotton

Table 2. Intercropping system and weed management practices on weed smothering efficiency (%) in cotton during summer 2016

Treatment	20 DAS					40 DAS					60 DAS				
	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean
PE *Prosopis juliflora* leaf extract 30% + one HW on 40 DAS	47.5	44.0	46.4	-	46.0	50.7	44.2	48.9	-	47.9	82.0	79.8	81.1	-	81.0
PE *Annona squamosa* leaf extract 30% + one HW on 40 DAS	40.5	33.4	37.8	-	37.2	42.2	30.3	36.7	-	36.4	79.4	77.1	78.6	-	78.4
PE *Mangifera indica* leaf extract 30% + one HW on 40 DAS	60.9	51.3	56.2	-	56.1	61.5	56.8	62.0	-	60.1	87.5	84.9	86.2	-	86.2
PE Pendimethalin 1.0 kg/ha + one HW on 40 DAS	75.9	71.6	74.6	-	74.0	67.0	66.1	66.5	-	66.5	92.7	91.1	91.7	-	91.8
Two HW at 20 and 40 DAS	28.4	24.5	27.0	-	26.6	76.8	72.4	75.7	-	75.0	95.1	94.3	94.8	-	94.7
Control (no weeding or spray)	20.0	11.2	16.3	-	15.8	16.4	7.1	13.1	-	12.2	19.5	8.0	13.6	-	13.7
Mean	45.5	39.3	43.0	-		52.4	46.1	50.5	-		76.0	72.5	74.3	-	

I_1- Cotton + Sorghum (1:1), I_2 - Cotton + Sunflower (1:1), I_3 - Cotton + Sesame (1:1), I_4- Sole cotton

Table 3. Effect of intercropping system and weed management practices on weed index (WI) in cotton during summer 2016 and winter 2016-17

Treatment	Summer 2016					Winter 2016-17				
	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean
PE *Prosopis juliflora* leaf extract 30% + one HW on 40 DAS	60.5	32.6	28.9	28.5	37.6	61.3	29.3	27.0	26.4	36.0
PE *Annona squamosa* leaf extract 30% + one HW on 40 DAS	63.5	41.8	35.3	34.6	43.8	64.0	41.7	32.6	31.2	42.4
PE *Mangifera indica* leaf extract 30% + one HW on 40 DAS	59.3	25.7	23.1	17.5	31.4	58.8	26.4	23.5	17.6	31.6
PE Pendimethalin 1.0 kg/ha + one HW on 40 DAS	46.7	16.9	15.9	12.8	23.1	53.4	14.5	11.9	11.5	22.8
Two HW at 20 and 40 DAS	46.2	10.0	3.6	0.0	15.0	44.8	8.3	7.1	0.0	15.1
Control (no weeding or spray)	72.3	70.7	67.5	65.9	69.1	75.0	73.5	70.6	68.7	72.0
Mean	58.1	33.0	29.1	26.6		59.6	32.3	28.8	25.9	

I_1- Cotton + Sorghum (1:1), I_2 - Cotton + Sunflower (1:1), I_3 - Cotton + Sesame (1:1), I_4- Sole cotton

plant which happened to be the seating points of sympodial branches. The relationship between increased number of sympodia due to increase in plant height in cotton was observed by Kuppusamy (1993) and Rajakumar (2000). Cotton + sorghum intercropping recorded lesser number of sympodia/ plant. Decrease in sympodia/plant of cotton under intercropped plots was possibly due to increased plant population per unit area resulting in severe competition between cotton and allelopathic intercrops for different growth resources and due to suppressive allelopathic effects exhibited by sorghum. Our results were at par with the findings of Aladakatti *et al*. (2011). Among the weed management practices, hand weeding twice at 20 and 40 DAS recorded a maximum number of sympodia/ plant during both the years. It was followed by the PE application of pendimethalin at 1.0 kg/ha + hand weeding at 40 DAS. Lesser number of sympodia/ plant was produced by the control.

Number of bolls

Intercropping system and weed management practices had significant bearing on number of bolls/ plant (**Table 4**). Sole cotton registered increased number of bolls/plant during both the seasons. However, it was at par with cotton + sesame intercropping system. The increase in boll numbers may be due to increase in plant height and corresponding increase in the sympodia/plant under sole cotton. Increased number of bolls under sole cotton was observed by Aladakatti *et al.* (2011). The suppressive effect on boll production was more pronounced in cotton + sorghum intercropping system. Reduction in boll number in cotton with sorghum as intercrop was mainly due to reduction in plant height, leaf area index and number of sympodia/ plant. Increased competition for growth factors with increased plant population per unit area under intercropped plots and allelopathic interference by intercrops might account for the decrease in number of bolls /plant. The reduction in yield parameters of cotton and in many other crops under various intercropping systems has also been documented by earlier researchers (Rathod *et al.* 2011). Among the weed management practices, hand weeding twice at 20 and 40 DAS produced higher number of bolls/ plant and it was followed by the application of PE pendimethalin at 1.0 kg/ha + hand weeding at 40 DAS. Lower number of bolls/plant was produced by the control.

Boll weight

Intercropping system and weed management practices had significant influence on boll weight during both summer 2016 and winter 2016-17 (**Table 4**). Higher boll weight was recorded in sole cotton, which was at par with boll obtained from cotton + sesame intercropping system. The increase in boll weight under sole cotton could be attributed to higher plant height, larger leaf area and improvement in leaf number resulting in increased photosynthesis leading to more accumulation of photosynthates in the bolls. This is in line with the findings of Aladakatti *et al.* (2011) and Ravindra Kumar *et al.* (2017). Lower boll weight was registered under cotton + sorghum intercropping system. Lower boll weight of cotton under sorghum intercropping condition was attributed to the insufficient supply of photosynthates for the development of bolls created by competitive nature of sorghum. Regarding weed management practices, hand weeding twice at 20 and 40 DAS resulted in heavier boll weight of cotton. This was at par with PE application of pendimethalin at 1.0 kg/ha + hand weeding at 40 DAS. Lower boll weight was observed from the control during both the years. The

Table 4. Pooled analysis of intercropping system and weed management practices on number of monopodia, number of sympodia, no. of bolls and boll weight of cotton during summer 2016 and winter 2016-17

Treatment	No. of monopodia/plant					No. of sympodia/plant					No. of bolls/plant					Boll weight (g)				
	I_I	I_2	I_3	I_4	Mean	I_I	I_2	I_3	I_4	Mean	I_I	I_2	I_3	I_4	Mean	I_I	I_2	I_3	I_4	Mean
W_1	1.07	1.43	1.47	1.47	1.36	5.8	9.8	10.3	10.8	9.2	12.3	21.2	21.7	22.0	19.3	2.42	2.7	2.77	2.82	2.68
W_2	1.07	1.27	1.30	1.37	1.25	5.5	8.5	9.1	9.5	8.2	11.8	18.7	20.0	20.6	17.8	2.36	2.6	2.64	2.68	2.57
W_3	1.07	1.47	1.50	1.74	1.45	6.4	11.5	11.9	12.5	10.6	12.9	24.5	25.6	25.9	22.2	2.44	3.0	3.06	3.18	2.92
W_4	1.20	1.74	1.80	1.83	1.64	7.0	13.0	13.5	13.8	11.8	13.3	26.8	27.1	27.4	23.7	2.49	3.2	3.32	3.34	3.09
W_5	1.27	1.94	2.00	2.10	1.83	7.9	14.3	14.9	15.7	13.2	13.5	28.9	29.2	30.4	25.5	2.55	3.4	3.44	3.54	3.23
W_6	1.07	1.07	1.07	1.07	1.07	4.1	4.3	4.6	5.1	4.5	10.4	10.6	11.0	11.2	10.8	2.24	2.3	2.30	2.34	2.30
Mean	1.12	1.48	1.52	1.59		6.1	10.2	10.7	11.2		12.3	21.8	22.4	22.9		2.41	2.9	2.92	2.98	
	I	W	I at W	W at I		I	W	I at W	W at I		I		I at W	W at I		I	W	I at W	W at I	
LSD (p=0.05)	0.07	0.08	0.16	0.16		0.3	0.5	1.1	1.1		0.8	0.9	2.0	1.9		0.12	0.16	0.32	0.32	

I_1- Cotton + Sorghum (1:1), I_2 - Cotton + Sunflower (1:1), I_3 - Cotton + Sesame (1:1), I_4- Sole cotton, W_1 - PE *Prosopis juliflora* leaf extract 30% + one HW on 40 DAS, W_2 - PE *Annona squamosa* leaf extract 30% + one HW on 40 DAS, W_3 - PE *Mangifera indica* leaf extract 30% + one HW on 40 DAS, W_4 - PE Pendimethalin 1.0 kg/ha + one HW on 40 DAS, W_5 - Two HW at 20 and 40 DAS and W_6 - Control (No weeding or spray)

yield attributes, *viz*. number of sympodia/plant, number of bolls/plant and boll weight was more with hand weeding twice at 20 and 40 DAS. This could be due to the enhanced plant height, dry matter production and nutrient uptake of the crop. This might also be due to the season long weed control which was favourable for better growth and enhanced leaf area contributing for the activated photosynthesis and translocation of more photosynthates to sink which increased the boll weight (Nalini 2010).

Seed cotton yield

During both the seasons of experimentation, intercropping and weed management practices had significant influence on seed cotton yield (**Table 5**). Higher seed cotton yield was recorded in sole cotton during summer 2016 and winter 2016-17 and it was at par with cotton + sesame intercropping system. This might be due to vigorous and quick growth of intercrops during early vegetative stage and slow growth of cotton which caused severe competition for the available resources leading to reduced plant height, leaf area index, dry matter production and all the yield components in cotton as evidenced in this study. These results were in conformity with Ravindra kumar *et al*. (2017). Intercropping of cotton + sorghum registered lower seed cotton yield.

Cotton + sorghum intercropping system resulted in maximum reduction of seed cotton yield to tune of 42.1 and 41.7% during summer 2016 and winter 2016-17, respectively, which was ascribed to much shading effect of sorghum on associated cotton due to its fast growth at earlier stage resulting in taller plants and possibly due to inter-specific competitive effect of sorghum on cotton. The reduction in seed cotton yield was also attributed to significant reduction in plant growth, sympodia/plant, number of boll/plant and boll weight. Reduction in seed cotton yield of cotton under intercropped plots may be reflective of competition and allelopathic effects of sorghum and sunflower. The results were in accordance with the findings of Aladakatti *et al*. (2011). The decrease in yield of cotton and other crops under various intercropping systems has also been reported by Rathod *et al*. (2011) and Oliveira *et al*. (2011).

Weed management practices on cotton had significant impact on seed cotton yield. Hand weeding twice at 20 and 40 DAS recorded higher seed cotton yield. This was at par with PE application of pendimethalin at 1.0 kg/ha + hand weeding at 40 DAS. The control registered lower seed cotton yield during both the seasons. The higher seed cotton yield under hand weeding twice at 20 and 40 DAS might be due to the least weed density which has shifted the competitive equilibrium in favour of crop over weeds. Thus, the crop under this treatment faced the least weed competition right from germination till the critical period. Nithya and Chinnusamy (2013) reported higher seed cotton yield of 69.3 to 72.0% with two hand weeding.

Cotton being a wide spaced and slow growing crop is sensitive to weed competition at early stages of growth than at later stages. Due to heavy infestation of weeds under unweeded control severe reduction in seed cotton yield was recorded. The crop under control might not be able to obtain the growth factors in optimum quantity resulting in reduced leaf area, dry matter production and poor yield. Presence of weeds throughout the growing season caused poor crop growth and caused yield reduction in unweeded check (Bhoi *et al*. 2007). Venugopalan *et al.* (2012) reported that cotton yield was directly related to increasing density of weed and it's duration of interference. In cotton, unweeded check registered upto 94.2% yield loss (Srinivasan and Venkatesan 2002). The reduction in yield was attributed to the cumulative effect of competition for space, nutrients and water.

Table 5. Effect of intercropping system and weed management practices on seed cotton yield (kg/ha) during summer 2016 and winter 2016-17

Treatment	Summer 2016					Winter 2016-17				
	I_1	I_2	I_3	I_4	Mean	I_1	I_2	I_3	I_4	Mean
PE *Prosopis juliflora* leaf extract 30% + one HW on 40 DAS	738	1436	1447	1453	1269	848	1511	1586	1652	1399
PE *Annona squamosa* leaf extract 30% + one HW on 40 DAS	689	1245	1347	1422	1176	788	1427	1458	1507	1295
PE *Mangifera indica* leaf extract 30% + one HW on 40 DAS	882	1457	1508	1614	1365	973	1694	1705	1816	1547
PE Pendimethalin 1.0 kg/ha + one HW on 40 DAS	1078	1699	1704	1731	1553	1226	1928	1949	1956	1765
Two HW at 20 and 40 DAS	1130	1738	1762	1799	1607	1237	1968	1997	2037	1810
Control (no weeding or spray)	444	470	522	556	498	559	592	657	689	624
Mean	827	1341	1382	1429		939	1520	1559	1610	
	I	W	I at W	W at I		I	W	I at W	W at I	
LSD (p=0.05)	57	78	153	156		63	87	171	174	

I_1- Cotton + Sorghum (1:1), I_2 - Cotton + Sunflower (1:1), I_3 - Cotton + Sesame (1:1), I_4- Sole cotton

Table 6. Intercropping system and weed management practices on economics of cotton during summer 2016 and winter 2016-17

Treatment	Cost of cultivation (x10^3 `/ha)	Gross return (x10^3 `/ha)	Net return (x10^3 `/ha)	B:C ratio
I_1W_1 - Cotton + sorghum (1:1) + PE *Prosopis juliflora* leaf extract 30% + HW at 40 DAS	60.59	47.59	-13.00	0.79
I_1W_2 - Cotton + sorghum (1:1) + PE *Annona squamosa* leaf extract 30% + HW at 40 DAS	60.59	44.85	-15.74	0.74
I_1W_3 - Cotton + sorghum (1:1) + PE *Mangifera indica* leaf extract 30% + HW at 40 DAS	60.59	53.92	-6.67	0.89
I_1W_4 - Cotton + sorghum (1:1) + PE pendimethalin 1.0 kg/ha + HW at DAS	49.48	64.28	14.80	1.30
I_1W_5 - Cotton + sorghum (1:1) + two hand weeding at 20 and 40 DAS	53.00	66.01	13.01	1.25
I_1W_6 - Cotton + sorghum (1:1) + control (no weeding or spray)	41.37	28.47	-12.90	0.69
I_2W_1 - Cotton + sunflower (1:1) + PE *Prosopis juliflora* leaf extract 30% + HW at 40 DAS	61.18	81.17	19.99	1.33
I_2W_2 - Cotton + sunflower (1:1) + PE *Annona squamosa* leaf extract 30% + HW at 40 DAS	61.18	74.12	12.94	1.22
I_2W_3 - Cotton + sunflower (1:1) + PE *Mangifera indica* leaf extract 30% + HW at 40 DAS	61.18	87.17	25.99	1.43
I_2W_4 - Cotton + sunflower (1:1) + PE pendimethalin 1.0 kg/ha + HW at 40 DAS	50.08	98.90	48.82	1.97
I_2W_5 - Cotton + sunflower (1:1) + two hand weeding at 20 and 40 DAS	53.59	101.56	47.97	1.90
I_2W_6 - Cotton + sunflower (1:1) + control (no weeding or spray)	41.96	29.84	-12.12	0.71
I_3W_1 - Cotton + sesame (1:1) + PE *Prosopis juliflora* leaf extract 30% + HW at 40 DAS	56.55	80.47	23.91	1.43
I_3W_2 - Cotton + sesame (1:1) + PE *Annona squamosa* leaf extract 30% + HW at 40 DAS	56.55	74.49	17.93	1.32
I_3W_3 - Cotton + sesame (1:1) + PE *Mangifera indica* leaf extract 30% + HW at 40 DAS	56.55	84.79	28.24	1.51
I_3W_4 - Cotton + sesame (1:1) + PE pendimethalin 1.0 kg/ha + HW at 40 DAS	49.20	96.22	47.02	1.96
I_3W_5 - Cotton + sesame (1:1) + two hand weeding at 20 and 40 DAS	52.71	99.30	46.59	1.88
I_3W_6 - Cotton + sesame (1:1) + control (no weeding or spray)	41.08	31.63	-9.45	0.77
I_4W_1 - Sole cotton + PE *Prosopis juliflora* leaf extract 30% + HW at DAS	56.54	69.86	13.32	1.23
I_4W_2 - Sole cotton + PE *Annona squamosa* leaf extract 30% + HW at 40 DAS	56.54	65.90	9.36	1.17
I_4W_3 - Sole cotton + PE *Mangifera indica* leaf extract 30% + HW at 40 DAS	56.54	77.17	20.63	1.37
I_4W_4 - Sole cotton + PE pendimethalin 1.0 kg/ha + HW at 40 DAS	45.43	82.96	37.52	1.82
I_4W_5 - Sole cotton + two hand weeding at 20 and 40 DAS	48.95	86.31	37.36	1.77
I_4W_6 - Sole cotton + control (no weeding or spray)	37.32	28.01	-9.31	0.75

Economics

The cost of cultivation was maximum under cotton + sunflower intercropping system. This was due to high cost of fertilizers and labour charges for harvesting (**Table 6**). Cost of cultivation was minimum with sole cotton. The highest net return and B: C ratio were obtained from the cotton + sunflower 1:1 proportion with pendimethalin 1.0 kg/ha as PE application followed by one hand weeding at 40 DAS and it was followed by cotton + sesame with pendimethalin 1.0 kg/ha as PE application followed by one hand weeding at 40 DAS. This was due to increased seed cotton yield and sunflower yield obtained in the above promising cropping system. Vekariya *et al.* (2015) reported that higher gross return, net return and B: C ratio were registered under cotton + sesame intercropping system. Cotton + sunflower intercropping system in 2:1 row proportion recorded higher gross income, net income and B: C ratio (Aladakatti *et al.* 2011). Lower net return, gross return and B: C ratio were obtained from cotton + sorghum intercropping system. This could be due to reduced cotton yield under above intercropping system.

Based on the experimental results, it could be concluded that cotton + sunflower intercropping system with PE application of pendimethalin at 1.0 kg/ha + hand weeding at 40 DAS or cotton + sesame intercropping system with PE application of pendimethalin at 1.0 kg/ha + hand weeding at 40 DAS was found ideal intercropping system for better weed control, higher yield and economic return.

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