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Rice Herbicides for Cotton + Soybean Intercropping

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A B S T R A C T

A field experiment was conducted at Central Institute for Cotton Research Farm, Nagpur for three years in medium deep clay loam soil. The experiment was laid out in RBD design with three replications consist of three herbicide based weed management packages in intercropping of non Bt cotton + soybean and two sole crops. Non Bt cotton+ soybean intercropping reduced seed cotton yields considerably in a year of very 640 mm higher rainfall over normal caused over growth of soybean. In second year also the seed cotton yields were low due to very high incidence of *Helicoverpa armigera* caused non recovery of intercropped cotton. The intercropped soybean grain yields were non significantly influenced in all the years by herbicide treatments and intercropping. The conventional herbicide package consists of Pendimethalin 0.75 kg a. i. ha^{-1} as PPI along with two interculture operations at 21 and 42 DAS was found to be most efficient. However, most economical and relatively efficient rice herbicides were Butachlor 1.0 kg as PPI or Oxyflurofen 0.1 kg a. i. ha^{-1} as pre emergence with two hoeings at 30 and 45 DAS and one hand weeding at 21 DAS to remove any herbicide resistant broad leaf weeds. All three herbicide packages tested were efficient economical and easily adoptable due to their local availability and all ready being used in rice ecosystem. Subsequently results were validated and demonstrated in Bt and non Bt hybrid cotton in station, on farm trials and farmers fields in the last 15 years.

Introduction

Non Bt cotton crop is widely spaced at 90cm row spacing under rainfed *vertisols* of central India. This wide space allows luxuriant weed growth in monsoon season that can be used for raising a short duration leguminous intercrops, which can suppress the weeds (Bonde and Raju 1996; Raju *et al*., 2013; Raju and Thakare, 2014). Non Bt cotton + soybean (1: 1) intercropping offers benefits such as insurance against crop failure due to aberrations in rainfall or out breaks of pest incidence with better profitability unit $area^{-1}$ and $time^{-1}$. Besides these the intercrop suppresses broad leaved weeds and root nodules contribute to soil fertility improvement. Screening of suitable varieties for intercropping in non Bt cotton at Central Institute for Cotton Research, Nagpur found non Bt cotton genotypes LRA 5166, hybrid-6 and soybean varieties Pusa-16, PKV-1, PK-472, TAS-40 and Punjab-1 were found suitable (Anon, 1994). Although non Bt cotton

and soybean were the major crops of this area and their intercropping is accepted on a limited scale due to inconvenience in crosswise intercultural operations. The other reasons for non-acceptance of earlier recommended intercrops like green and black gram is catching intercrops in post September rains. Nimbole (1990) suggested to use Fluchloralin a, dinitro aniline herbicide in intercropping of non Bt hybrid cotton. The primary objective of this experiment was to adopt and develop the rice herbicides based low cost integrated weed management package for intercropped non Bt cotton. Therefore, a field experiment was planned to study the effective and economic rice herbicide based integrated weed management package for non Bt cotton + soybean intercropping.

Materials and Methods

The field experiment was planted in monsoon season with 3 herbicides and two earthingups based integrated weed management treatments of non Bt cotton + soybean row intercropping and three controls i.e. Farmer's practice and two sole crops in R.B.D. design with three replications in medium deep *vertisols*. The intercropped non Bt cotton was planted at 90 x 15 cm and soybean at 30 cm in rows, sole crop treatments of non Bt cotton was planted at 60 x 30 cm and soybean at 45 x 15 cm as per recommendation. The fertilizers were applied to both the crops as per their respective recommended doses of fertilizers (R.D.F.) i. e. 60:30:30 and 20: 50: 0 kg N, P_2O_5 and K_2O respectively in proportion to their population for non Bt cotton and soybean crops, whereas for intercropping of soybean 60% RDF was supplemented in addition to 100 % RDF for non Bt cotton. Intercultural operations were performed in rows in one direction only. The treatment details are T_1: Pendimethalin herbicide @ 0.75 kg a. i. ha^{-1} as pre plant incorporation (PPI) + two interculture operations at 21 and 42 DAS; T_2: Two intercultural operations at 21, 42 DAS followed by two earthingup operations; T_3: Two intercultural operations at 21, 42 DAS followed by one hand weeding along with earthingup operation after first interculture operation; T_4: Two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS (check); T_5: Oxyflurofen 0.1 kg a. i. ha^{-1} as pre emergence with 2 intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS to remove resistant broad leaved weeds; T_6: Butachlor 1.0 kg a. i. ha^{-1} as PPI with two intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS to remove resistant broad leaved weeds (one year); T_7: Sole crop of non Bt cotton C. *var*. LRA 5166 with recommended cultural weed management i.e. Three intercultural operations at 21, 42 and 63 DAS followed by two hand weedings at 21 and 42 DAS ; T_8: Sole crop of soybean C. var. Punjab-1 with two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS. The herbicides tolerance was evaluated in pot trial for non Bt cotton and soybean before starting of field trial. The weed populations were converted to log V(x+21) before statistical analysis.

Results and Discussion

Weed density M^2

The common weed flora of the experimental site were *Phylanthus niruri, Celocia argentia, Convolvulus arvensis, Euphorbea geniculata, E. macrocephala, Cynotis auxillaris, Merremia emarginata, Panicum repense, Thelepogon elegans, Digitaria ciliaris and Echinocloa colonum* were observed. In first season, the weed management treatments were significantly influenced on Di cots and total weed population (Table.1). Non Bt cotton + soybean intercropping has successfully

suppressed weeds compared to both the sole crops. The soybean as sole crop had highest dicot weed population at the time of first interculture. Oxyflurofen herbicide had significantly lowest weed density while pendimethalin had statistically similar weed populations to that of intercultures along with hand weedings.

After the second interculture only total weed population was influenced and no distinction within sole and intercrops was observed probably due to weed suppression by soybean canopy coverage and residual influence of herbicide treatments. Farmer's practice of three intercultures and hand weedings had significantly lowest weed density, which was at par with oxyflurofen herbicides as pre emergence application.

In second season, at the time of first interculture oxyflurofen as pre em application had significantly lowest weed density (Table. 2) compared to normal cultural practices treatment. Mono cot weeds population was reduced by 90% and di cots by 50% by Oxyflurofen pre emergence spray without harming cotton or soybean. Similarly, the differences within treatments T_3, T_4 and T_7, T_8 were at par. There was no distinction between sole and inter crops for weed density due 1.5 times excess rains received and intercropped soybean over grown and suppress the weeds.

After second interculture the dicots population reduced to minimal due to interculture effect but mono cots population remained as such and therefore treatment differences were reduced to non-significant level. This probably due to faster leaf expansion of soybean under cloudy weather and higher rainfall lead to early canopy closing. In the final year monsoon season weed density of monocot weeds were non significantly removed by 1st interculture (Table 3) and hand weeding in sole and inter crops.

Butachlor as PPI application was relatively more efficient in controlling dicot weeds compared to oxyflurofen as pre em application and rest were at par. Among total weed densities treatments T_5 and T_6 were at par while they had significantly higher weed density patches than normal intercultures and hand weedings (T_4).

At the time of second interculture and hand weeding monocot weeds were non significantly influenced by sole and intercrops (Table. 4). Similarly was with dicot weeds by second interculture except treatments T_5 and T_6 i.e. rice herbicides had higher dicot weeds. At the time of 3rd. interculture after harvesting of intercrop hand weeding significantly removed (Table.5) monocot weeds which were higher in sole crops, treatment T_6 had significantly higher monocot weeds than farmer's practice (T_4), while rice herbicides T_5 and T_6 were statistically at par. Therefore the butachlor efficacy needs to be confirmed with further studies.

Weed biomass

Weed biomass was non significantly differing (Table. 6) by sole and intercrops. Pendimethalin (T_1) and farmer's practice along with earthingups (T_3) had significantly lower biomass than treatment farmer's practice alone (T_4).

Additional hand weeding at 21 DAS in treatment T_3 proved its effectiveness in rainy season with continuous rains. On 1st hand weeding the treatment differences failed to influence on weed biomass. At the time of 2nd interculture and hand weeding treatment along with Pendimethalin in treatment T_1 had higher weeds because of dry weather subsequently to its application. Rice herbicide treatments Butachlor (T_5) and oxyflurofen (T_6) had lowest weed biomass among all the weed management treatments.

Table.1 Weed density M^2 by hand weeding in first season

T. No	hand weeding 22 July			hand weeding 7th September		
	Mono cots	Di cots	Total	Mono cots	Di cots	Total
T_1: Pendimethalin @ 0.75 kg a. i. ha^{-1} as PPI + two interculture operations at 21 and 42 DAS.		1.33 (0.6743)	1.33 (0.6743)			
T_2: Two intercultural operations at 21, 42 DAS followed by two earthingup operations.	0.33 (0.6645)	2.16 (0.6823)	2.5 (0.6854)			
T_3: Two intercultural operations at 21, 42 DAS followed by one hand weeding alongwith earthingup operation.	0.33 (0.6645)	1.83 (0.6792)	2.16 (0.6624)			
T_4: Two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.	0.66 (0.6678)	2.0 (0.6805)	2.66 (0.6838)	0.5 (0.6662)	1.83 (0.6792)	2.33 (0.6774)
T_5: Oxyflurofen 0.1 kg a. i. ha^{-1} as pre emergence with 2 intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS.		0.16 (0.6628)	0.16 (0.6628)	0.33 (0.6645)	2.33 (0.6839)	2.66 (0.6787)
T_7: Sole crop of non Bt cotton C. *var*. LRA 5166 with recommended cultural weed management i.e. Three intercultural operations at 21, 42 and 63 DAS followed by two hand weedings at 21 and 42 DAS.	0.33 (0.6645)	5.33 (0.7095)	5.66 (0.7120)	2.33 (0.6774)	2.33 (0.6774)	4.68 (0.6973)
T_8: Sole crop of soybean C. var. Punjab-1 with two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.		9.83 (0.7438)	9.83 (0.7438)	1.33 (0.6743)	2.66(0.6787)	4.0 (0.6901)
SED ±5 %	0.0025			0.0275	0.0112	
CD±5 %	NS	0.0214	0.0201	NS	NS	0.0189

Table.2 Weed density M^2 by hand weeding in second season

T.No	30th July			31st August.		
	Mono cots	Di cots	Total	Mono cots	Di cots	Total
T_1: Pendimethalin @ 0.75 kg a. i. ha^{-1} as PPI + two interculture operations at 21 and 42 DAS.						
T_2: Two intercultural operations at 21, 42 DAS followed by two earthingup operations.						
T_3: Two intercultural operations at 21, 42 DAS followed by one hand weeding alongwith earthingup operation.	5.5 (0.710)	8.16 (0.731)	13.66 (0.766)			
T_4: Two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.	10.16 (0.741)	10.33 (0.744)	20.5 (0.808)	10.17 (0.743)	2.83 (0.688)	13.0 (0.761)
T_5: Oxyflurofen 0.1 kg a. i. ha^{-1} as pre emergence with 2 intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS.	1.0 (0.670)	5.66 (0.709)	6.66 (0.717)	9.17 (0.738)	2.33 (0.683)	11.5 (0.755)
T_7: Sole crop of non Bt cotton C. *var*. LRA 5166 with recommended cultural weed management i.e. Three intercultural operations at 21, 42 and 63 DAS followed by two hand weedings at 21 and 42 DAS.	7.0 (0.719)	12.0 (0.758)	22.33 (0.817)	6.17 (0.716)	4.5 (0.703)	10.7 (0.749)
T_8: Sole crop of soybean C. var. Punjab-1 with two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.	7.16 (0.723)	10.16 (0.746)	17.33 (0.791)	5.33 (0.710)	6.17 (0.715)	11.5 (0.755)
SED ±5 %	0.022	0.001		0.014	0.040	0.015
CD±5 %	NS	NS	0.066	NS	NS	NS

Table.3 Weed density M^2 on 26th July third season

T.No	Interculture			Hand weeding		
	Mono cots	Di cots	Total	Monocots	Di cots	Total
T_1: Pendimethalin @ 0.75 kg a. i. ha^{-1} as PPI + two interculture operations at 21 and 42 DAS.				0.99 (0.518)	3.0 (0.689)	3.99 (0.698)
T_2: Two intercultural operations at 21, 42 DAS followed by two earthingup operations.	1.78 (0.698)	2.44 (0.684)	4.22 (0.700)	1.33 (0.674)	1.84 (0.672)	2.10 (0.681)
T_3: Two intercultural operations at 21, 42 DAS followed by one hand weeding alongwith earthingup operation.	2.78 (0.687)	1.55 (0.676)	4.33 (0.701)	2.0 (0.680)	1.55 (0.673)	3.54 (0.694)
T_4: Two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.	1.67 (0.677)	2.44 (0.684)	4.11 (0.699)	1.55 (0.674)	1.89 (0.679)	3.44 (0.694)
T_5: Oxyflurofen 0.1 kg a. i. ha^{-1} as pre emergence with 2 intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS.	3.22 (0.691)	5.44 (0.711)	8.66 (0.735)	0.83 (0.669)	1.66 (0.677)	3.88 (0.697)
T_6: Butachlor 1.0 kg a. i. ha^{-1} as PPI with two intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS	2.44 (0.684)	4.78 (0.705)	7.22 (0.725)	1.99 (0.680)	1.66 (0.677)	3.88 (0.697)
T_7: Sole crop of non Bt cotton C. *var*. LRA 5166 with recommended cultural weed management i.e. Three intercultural operations at 21, 42 and 63 DAS followed by two hand weedings at 21 and 42 DAS.	1.56 (0.676)	2.0 (0.680)	3.55 (0.695)	2.0 (0.680)	1.67 (0.677)	3.66 (0.696)
T_8: Sole crop of soybean C. var. Punjab-1 with two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.	1.56 (0.676)	2.0 (0.680)	3.55 (0.690)	2.89 (0.688)	1.44 (0.675)	4.3 (0.701)
SED ±5 %	0.059			0.054	0.004	0.062
CD±5 %	NS	0.016	0.021	NS	NS	NS

Table.4 Weed density M^2 on 9th August third season

T.No	Interculture			Hand weeding		
	Mono cots	Di cots	Total	Mono cots	Di cots	Total
T_1: Pendimethalin @ 0.75 kg a. i. ha^{-1} as PPI + two interculture operations at 21 and 42 DAS.	1.77 (0.679)	1.66 (0.674)	3.43 (0.691)	2.22 (0.681)	5.22 (0.708)	7.60 (0.728)
T_2: Two intercultural operations at 21, 42 DAS followed by two earthingup operations.	1.66 (0.678)	0.55 (0.666)	2.21 (0.678)	2.33 (0.683)	2.66 (0.687)	2.99 (0.699)
T_3: Two intercultural operations at 21, 42 DAS followed by one hand weeding along with earthingup operation.	1.33 (0.679)	1.22 (0.673)	2.55 (0.681)	2.11 (0.681)	2.55 (0.684)	4.66 (0.703)
T_4: Two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.	1.88 (0.680)	0.88 (0.670)	2.77 (0.682)	2.66 (0.683)	3.66 (0.695)	6.32 (0.709)
T_5: Oxyflurofen 0.1 kg a. i. ha^{-1} as pre emergence with 2 intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS.	1.44 (0.676)	2.88 (0.688)	4.33 (0.696)	0.86 (0.669)	2.55 (0.685)	3.43 (0.691)
T_6: Butachlor 1.0 kg a. i. ha^{-1} as PPI with two intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS	2.77 (0.688)	2.55 (0.685)	5.32 (0.701)	2.44 (0.684)	2.22 (0.682)	4.66 (0.700)
T_7: Sole crop of non Bt cotton C. *var*. LRA 5166 with recommended cultural weed management i.e. Three intercultural operations at 21, 42 and 63 DAS followed by two hand weedings at 21 and 42 DAS.	1.88 (0.680)	1.11 (0.672)	2.99 (0.682)	3.44 (0.693)	3.33 (0.692)	6.76 (0.705)
T_8: Sole crop of soybean C. var. Punjab-1 with two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.	1.55 (0.678)	0.55 (0.666)	2.10 (0.677)	3.0 (0.689)	1.0 (0.671)	3.99 (0.682)
SED ±5 %	0.003		0.005	0.009	0.009	0.008
CD±5 %	NS	0.012	NS	NS	NS	NS

Table.5 Weed density M^2 on 21st October third season

T. No	Hand weeding		
	Mono cots	Di cots	Total
T_1: Pendimethalin @ 0.75 kg a. i. ha^{-1} as PPI + two interculture operations at 21 and 42 DAS.	3.0 (0.680)	3.16 (0.690)	5.16 (0.702)
T_2: Two intercultural operations at 21, 42 DAS followed by two earthingup operations.	3.16 (0.691)	4.66 (0.703)	7.83 (0.716)
T_3: Two intercultural operations at 21, 42 DAS followed by one hand weeding along with earthingup operation.	2.5 (0.685)	3.83 (0.697)	6.33 (0.705)
T_4: Two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.	2.16 (0.682)	5.33 (0.709)	7.50 (0.720)
T_5: Oxyflurofen 0.1 kg a. i. ha^{-1} as pre emergence with 2 intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS.	5.33 (0.706)	3.16 (0.691)	8.5 (0.702)
T_6: Butachlor 1.0 kg a. i. ha^{-1} as PPI with two intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS	7.66 (0.725)	3.0 (0.689)	10.66 (0.725)
T_7: Sole crop of non Bt cotton C. *var*. LRA 5166 with recommended cultural weed management i.e. Three intercultural operations at 21, 42 and 63 DAS followed by two hand weedings at 21 and 42 DAS.	7.83 (0.728)	2.0 (0.680)	9.83 (0.713)
T_8: Sole crop of soybean C. var. Punjab-1 with two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.	7.33 (0.745)	5.3 (0.709)	11.16 (0.724)
SED ±5 %		0.028	0.013
CD±5 %	0.040	NS	NS

Table.6 Weed biomass g M^2 in third season.

T.No	30th June.			26th. July.			9th August.		
	Inter culture	Hand weeding	Total	Inter culture	Hand weeding	Total	Inter culture	Hand weeding	Total
T_1: Pendimethalin @ 0.75 kg a. i. ha^{-1} as PPI + two interculture operations at 21 and 42 DAS.	4.13		4.13		1.33	1.33	1.88	2.78	4.66
T_2: Two intercultural operations at 21, 42 DAS followed by two earthingup operations.	18		18	2.16	1.16	3.33	1.33	2.94	4.27
T_3: Two intercultural operations at 21, 42 DAS followed by one hand weeding along with earthingup operation.	2.67		2.67	3.33	1.83	5.16	1.55	2.22	3.77
T_4: Two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.	5.3	8.1	13.4	3.33	2	5.33	1.66	1.67	3.33
T_5: Oxyflurofen 0.1 kg a. i. ha^{-1} as pre emergence with 2 intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS.	1.17	8.77	9.93	2.16	5	5	1	0.56	1.56
T_6: Butachlor 1.0 kg a. i. ha^{-1} as PPI with two intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS				4.33	2.33	6.66	0.89	0.44	1.33
T_7: Sole crop of non Bt cotton C. *var*. LRA 5166 with recommended cultural weed management i.e. Three intercultural operations at 21, 42 and 63 DAS followed by two hand weedings at 21 and 42 DAS.	6.37	9.13	15.83	2.83	1.83	4.66	1.66	2	3.66
T_8: Sole crop of soybean C. var. Punjab-1 with two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.	6.8	8.3	15.1	2.33	3	5.33	2.44	2.22	4.66
SED ±5 %				0.93	1.58	1	0.38		
CD±5 %			7.69	NS	NS	NS	NS	0.89	

*Figures in parenthesis are log V(x+21)

Table.7 LER values by weed management strategies

Tr. No	Seed cotton yields Kg ha^{-1}				Soybean yield Kg ha^{-1}				LER values for intercropping			
	Year I	Year II	Year III	Mean	Year I	Year II	Year III	Mean	Year I	Year II	Year III	Mean
T_1: Pendimethalin @ 0.75 kg a. i. ha^{-1} as PPI + two interculture operations at 21 and 42 DAS.	1061	257	421	580	1675	661	578	971	2.05	1.22	2.36	1.88
T_2: Two intercultural operations at 21, 42 DAS followed by two earthingup operations.	978	217	257	484	1360	595	793	916	1.92	1.09	1.91	1.64
T_3: Two intercultural operations at 21, 42 DAS followed by one hand weeding along with earthingup operation.	1048	228	271	515	1551	660	811	1007	2.07	1.20	2.01	1.76
T_4: Two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.	1072	254	258	528	1532	708	869	1036	2.16	1.29	2.06	1.84
T_5: Oxyflurofen 0.1 kg a. i. ha^{-1} as pre emergence with 2 intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS.	1073	427	254	585	1293	797	811	967	1.98	1.58	1.97	1.84
T_6: Butachlor 1.0 kg a. i. ha^{-1} as PPI with two intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS	-		256	256			813	813			1.98	1.98
T_7: Sole crop of non Bt cotton C. *var*. LRA 5166 with recommended cultural weed management i.e. Three intercultural operations at 21, 42 and 63 DAS followed by two hand weedings at 21 and 42 DAS	1083	1171	251	835								
T_8: Sole crop of soybean C. var. Punjab-1 with two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.	-				1309	654	876	946	1	1	1	1
SED ±5 %	67.0				98.8	62.7	94.1					
CD±5 %		176	101						0.24	0.12	0.5	

Table.8 Profitability of cotton–soybean intercropping system with herbicides

Tr. No	**Weed management cost Rs ha^{-1}**				**B:C ratio**			
	Year I	**Year II**	**Year III**	**Mean**	**Year I**	**Year II**	**Year III**	**Mean**
T_1: Pendimethalin @ 0.75 kg a. i. ha^{-1} as PPI + two interculture operations at 21 and 42 DAS.	1285	1934	1356	1525	3.76	1.59	1.61	2.32
T_2: Two intercultural operations at 21, 42 DAS followed by two earthingup operations.	769	1158	965	964	3.07	1.32	1.40	1.93
T_3: Two intercultural operations at 21, 42 DAS followed by one hand weeding along with earthingup operation.	801	1148	937	962	3.41	1.44	1.46	2.10
T_4: Two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.	2467	1961	1087	1838	4.16	1.66	1.5	2.44
T_5: Oxyflurofen 0.1 kg a. i. ha^{-1} as pre emergence with 2 intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS.	1936	1588	949	1491	3.57	2.29	1.41	2.43
T_6: Butachlor 1.0 kg a. i. ha^{-1} as PPI with two intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS			861	861			1.34	1.34
T_7: Sole crop of non Bt cotton C. *var*. LRA 5166 with recommended cultural weed management i.e. Three intercultural operations at 21, 42 and 63 DAS followed by two hand weedings at 21 and 42 DAS.	2853	2075	1146	2024	2.18	3.93	0.53	2.21
T_8: Sole crop of soybean C. var. Punjab-1 with two intercultural operations at 21, 42 DAS followed by two hand weedings at 21 and 42 DAS.	2537	1882	603	1674	1.91	1.01	1.09	1.33
CD±5 %	1053	309	193					

Seed cotton and soybean grain yields

The results found in three seasons highest LER of 2.16, 1.58 and 2.36 were observed, the lowest value of 1.58 was due to excess rains caused excess vegetative growth of soybean reduced seed cotton yield of intercropping. Despite these draw backs for both the crops a mean LER of 1.98 was observed over 3 years which clearly indicates the profitability of cotton + soybean intercropping with reasonably acceptable weed management. The seed cotton and soybean grain yields were non significantly influenced in first season due to efficient distribution of rainfall non Bt cotton compensated from its reduction in growth. In 2nd season due to intercropping soybean yields were non significantly reduced but in non Bt cotton significant reduction in yields were observed compared to sole non Bt cotton but the weed management treatments remained at non-significant level due to higher growth of soybean under excess rains. In 3rd season also soybean results due to intercropping were unaffected but seed cotton yield significantly improved with the Pendimethalin herbicide @ 0.75 kg a. i. ha^{-1} as P.P.I. + 2 intercultural operations at 21 and 42 DAS. LER values also indicates in treatment T_2 (2 intercultural operations at 21, 42 DAS followed by two earthingup operations) significant differences were observed due to earthingup operations which did not suppressed the weeds under excess rains, whereas Oxyflurofen 0.1 kg a. i. ha^{-1} as pre emergence with 2 intercultural operations at 30 and 45 DAS followed by one hand weeding at 21 DAS to remove resistant broad leaved weeds significantly outperformed over farmer's practice in 2nd season. LER values in 3rd season were significantly higher than sole crops but among weed management treatments differences remains at non-significant levels. The economic indicators like C:B ratio on average over three years suggested Oxyflurofen 0.1 kg a. i. ha^{-1} as pre emergence and two intercultures and hand weedings at 21 and 42 DAS are most economical followed by Pendimethalin herbicide @ 0.75 kg a. i. ha^{-1} as PPI in non Bt cotton–soybean intercropping with + 2 interculture operations at 21 and 42 DAS Butachlor @ 0.75 kg a. i. ha^{-1} as PPI was also evaluated in one year which was also economical in non Bt cotton–soybean intercropping. Butachlor field efficacy was further confirmed from other field studies at this institute which found it was equally effective. The results were in conformity with Nimbole, 1990 and Ramesh Babu and Rao, 1993.

Therefore the economic and effective integrated weed management packages were recommended for non Bt cotton-soybean intercropping involving low cost herbicides such as Oxyflurofen @ 0.1 kg a. i. ha^{-1} as pre emergence and Butachlor 1.0 kg a. i. ha^{-1} as PPI along with two interculture operations at 21 and 42 days after sowing and if any resistant weeds are there which can be removed by hand weeding.

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