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Effect of Sequential Application of Herbicides on Weed Dynamics, Growth and Yield of Rainfed Cotton

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ABSTRACT

Field experiment was conducted during *Kharif,* 2011 at the Agricultural College Farm, Bapatla of Acharya N.G. Ranga Agricultural University to study the effect of sequential application of herbicides on weed dynamics, growth and yield of rainfed cotton. Results indicated that lower weed count and dry weight of weeds, higher weed control efficiency as well as plant height, monopodial, sympodial branches, number of bolls, seed cotton yield, net returns and benefit cost ratio were found with the farmer's practice. Among the herbicidal combinations, pre-emergence application of pendimethalin @ 1.5 kg *a.i* ha^{-1} followed by post-emergence application of pyrithiobac @ 63 g *a.i* ha^{-1} significantly reduced the density and dry weight of weeds and resulted in higher weed control efficiency, plant height, sympodial branches, number of bolls, seed cotton yield, net returns and benefit cost ratio.

Key words : Fenoxaprop ethyl, Pyrithiobac and benefit cost ratio, Quizalofop ethyl, Sequential application of herbicides,Weed control efficiency.

Cotton (*Gossypium hirsutum* L.) is an important commercial crop of India grown for its lint used as a major textile fibre, which is aptly called as "King of fibres" or "White Gold". It plays an important role in the textile industry and is means of livelihood for millions of farmers and those concerned with its trade, processing, manufacturing and other allied industries. The area, production and productivity of cotton crop in Andhra Pradesh during 2010-11 was 17.10 lakh hectares, 65.38 lakh bales and 653 kg ha^{-1} respectively (AICCIP, Annual report, 2010-11).

The productivity of cotton in India (503kg ha^{-1}) is very low compared to world2 s productivity (759 kg ha^{-1}). There are several constraints for low productivity of cotton like competition from weeds, micronutrient deficiency (Boron and Zinc), boll shedding, leaf reddening, sucking pests and poor agronomic practices. Among these constraints, the most troublesome one is competition from weeds. Cotton being a wide spaced and long duration crop, suffers from heavy weed competition during the early stages of crop growth. Critical period of crop weed competition is 60 to 70 days from sowing (Makhankova and Voevodin, 1984). The weed problem gets more severe due to certain unforeseen factors such as inefficient weeding or interculture coupled with continuous rains during early crop growth period. Removal of weeds manually is costly, time demanding and less effective. Most of the weeds, particularly those growing in intra rows or nearer to the base of plant escape from intercultivation. So, use of herbicides is one of the best option to avoid the competition from weeds during the critical period of crop growth. Pre-emergence herbicides at recommended doses are generally capable of controlling annual weeds upto a period of 30 days (Pawar *et al*. 2000). Concentration of herbicides in soil decreases due to the short half life of herbicide molecules leading to emergence of susceptible weed species beyond 30 days after application of herbicides. In the absence of intercultural operations and with regular monsoon rains, weeds germinate in different spells and compete with crop plants and finally reduce the seed cotton yield. Hence, there is a need to go for sequential application of pre-emergence followed by post-emergence herbicides to manage the late emerging weeds to eliminate weed competition throughout the critical period (Pawar *et al*. 2000). Hence, present investigation was conducted to

Table1. Density (No. m^{-2}), dry weight (g m^{-2}) of weeds and WCE (%) as influenced by sequential application of herbicides in cotton

Treatments	Weed density (No. m^{-2})	Weed dry weight (g m^{-2})	Weed control efficiency (%)
T_1: Weedy Check	16.26 (264)	195.00	-
T_2: Hand weeding twice at 30 and 60 DAS	12.11 (147)	65.27	75.1
T_3: Pendimethalin @ 1.5 kg a.i ha^{-1} as PRE	14.06 (198)	149.33	23.5
T_4: Pendimethalin @ 1.5 kg a.i ha^{-1} fb. interculture at 40 DAS	12.41 (154)	73.13	62.3
T_5: Pendimethalin @ 1.5 kg a.i ha^{-1} fb. fenoxaprop ethyl @ 56 g a.i ha^{-1} at 40 DAS	14.10 (199)	128.13	34.3
T_6: Pendimethalin @ 1.5 kg a.i ha^{-1} fb. quizalofop ethyl @ 50 g a.i ha^{-1} at 40 DAS	13.25 (175)	113.80	41.6
T_7: Pendimethalin @ 1.5 kg a.i ha^{-1} fb. pyrithiobac @ 63 g a.i ha^{-1} at 40 DAS	12.82 (164)	85.07	56.6
T_8: Interculture at 20 DAS fb. fenoxaprop ethyl @ 56 g a.i ha^{-1} at 40 DAS	12.86 (165)	129.93	36.9
T_9: Interculture at 20 DAS fb. quizalofop ethyl @ 50 g a.i ha^{-1} at 40 DAS	13.59 (185)	109.80	43.6
T_{10}: Interculture at 20 DAS fb. pyrithiobac @ 63 g a.i ha^{-1} at 40 DAS	12.55 (158)	92.63	52.4
T_{11}: Farmer's Practice	9.24 (85)	25.73	86.7
SEm $\pm$	0.53	8.78	4.0
CD (p=0.05)	1.57	25.89	11.7
CV %	7.11	14.32	14.8

Note: Figures in the parentheses are original values; Square root transformations ($\sqrt{x+0.5}$) used for statistical analysis

evaluate the effect of sequential application of herbicides on weed dynamics, growth and yield of rainfed cotton.

MATERIAL AND METHODS

A field experiment was conducted at the Agricultural College Farm, Bapatla of Acharya N.G. Ranga Agricultural University during *Kharif* 2011. The experiment was laid out in a randomized block design with three replications and eleven treatments viz., T_1- Weedy check; T_2- Hand weeding twice at 30 and 60 DAS; T_3- Pendimethalin @ 1.5 kg a.i ha^{-1} as pre-emergence; T_4- Pendimethalin @ 1.5 kg a.i ha^{-1} as pre-emergence followed by interculture at 40 DAS; T_5- Pendimethalin @ 1.5 kg a.i. ha^{-1}as pre-emergence followed by fenoxaprop ethyl @ 56 g a.i ha^{-1} as post-emergence at 40 DAS; T_6- Pendimethalin @ 1.0 kg a.i. ha^{-1}as pre-emergence followed by quizalofop @ 50 g a.i. ha^{-1} as post-emergence at 40 DAS; T_7- Pendimethalin @ 1.5 kg a.i. ha^{-1} followed by pyrithiobac @ 63 g a.i. ha^{-1} as post-emergence at 40 DAS and T_8- Interculture at 20 DAS followed by fenoxaprop ethyl @ 56 g a.i ha^{-1} at 40 DAS; T_9- Interculture at 20 DAS followed by quizalofop ethyl @ 50 g a.i ha^{-1} at 40 DAS; T_{10}- Interculture at 20 DAS followed by pyrithiobac @ 63 g a.i ha^{-1} at 40 DAS; T_{11}-Farmer's practice (hand weeding/inter culture four times at 15 days interval). The soil of the experimental field was clay loam in texture with p^H 7.8 and was medium in organic carbon (0.52 %), low in available nitrogen (178 kg ha^{-1}), medium in available phosphorus (29 kg ha^{-1}) and high in available potassium (384 kg ha^{-1}). Annual rainfall of 765.1 mm was received in 39 rainy days during crop growth period against normal rainfall of 902 mm in 49 rainy days. Cotton hybrid Bunny Gold *Bt-2* was dibbled at 90 cm x 60 cm spacing on 1st August, 2011. Crop was fertilized with a recommended dose

Table 2. Growth and seed cotton yield as influenced by sequential application of herbicides in cotton

Treatments	Plant height (cm)	Monopodial branches $plant^{-1}$	Sympodial branches $plant^{-1}$	No. of bolls $plant^{-1}$	Seed cotton (kg ha^{-1})	WI (%)
T_1: Weedy Check	79.3	0.81 (0.20)	33.6	18.3	1422	56.8
T_2: Hand weeding twice at 30 and 60 DAS	110.0	1.21 (1.00)	72.8	35.3	2652	17.9
T_3: Pendimethalin @ 1.5 kg a.i ha^{-1} as PRE	93.0	0.95 (0.47)	47.7	28.0	2136	34.0
T_4: Pendimethalin @ 1.5 kg a.i ha^{-1} fb. interculture at 40 DAS	98.3	0.93 (0.47)	61.9	31.3	2437	24.5
T_5: Pendimethalin @ 1.5 kg a.i ha^{-1} fb. fenoxaprop ethyl @ 56 g a.i ha^{-1} at 40 DAS	88.0	0.90 (0.40)	48.0	27.3	2140	33.8
T_6: Pendimethalin @ 1.5 kg a.i ha^{-1} fb. quizalofop ethyl @ 50 g a.i ha^{-1} at 40 DAS	91.7	0.93 (0.47)	51.0	27.3	2034	36.2
T_7: Pendimethalin @ 1.5 kg a.i ha^{-1} fb. pyrithiobac @ 63 g a.i ha^{-1} at 40 DAS	94.4	1.00 (0.60)	61.1	28.3	2380	26.4
T_8: Interculture at 20 DAS fb. fenoxaprop ethyl @ 56 g a.i ha^{-1} at 40 DAS	93.3	0.97 (0.53)	57.9	27.3	2124	34.3
T_9: Interculture at 20 DAS fb. quizalofop ethyl @ 50 g a.i ha^{-1} at 40 DAS	92.3	0.97 (0.53)	50.1	26.0	2150	32.6
T_{10}: Interculture at 20 DAS fb. pyrithiobac @ 63 g a.i ha^{-1} at 40 DAS	97.3	1.00 (0.60)	60.7	31.0	2468	23.3
T_{11}: Farmer's Practice	128.3	1.44 (1.60)	97.1	41.7	3252	-
SEm $\pm$	5.4	0.06	3.6	2.4	137.3	4.1
CD (p=0.05)	15.8	0.18	10.6	7.0	405.2	12.1
CV %	9.6	10.73	10.7	14.1	10.4	24.3

Note: Figures in the parentheses are original values; Square root transformations ($\sqrt{x+0.5}$) used for statistical analysis

of 120:60:60 kg N, P_2O_5 and K_2O ha^{-1}. Pendimethalin was applied on the same day of sowing and other post-emergence herbicides were applied at 40 DAS by using knapsack sprayer with a spray volume of 500 l ha^{-1}. Data on weed density and dry weight were recorded by using quadrate of 0.25 m x 0.25 m from four locations of plot at random. The weed count data were subjected to square root transformations before statistical analysis. Seed cotton was harvested by three pickings on 13.12.2011, 30.12.2011 and 21.01.2012, respectively.

RESULTS AND DISCUSSION

The weed species which infested the experimental plot were *Cynodon dactylon, Dactyloctenium aegyptium, Digitaria sanguinalis* (L.) Scop., *Echinochloa colonum, Panicum repens* Linn., (grasses) *Cyperus rotundus* Linn., (sedge) and broad leaved weeds viz., *Acalypha indica* Linn., *Acalypha ciliata, Achyranthes aspera, Aristolochia bracteata* Retz., *Cleome viscosa* Linn., *Commelina benghalensis* Linn., *Corchorus trilocularis* Linn., *Cynotis cucullata* Kurtz., *Digera arvensis* Forsk, *Euphobia hirta, Euphorbia geneculata, Merrimia emerginata* Hallier., *Physalis minima, Phyllanthus madrapataensis* Linn., *Trianthema portulacastrum*, Linn. and *Tridax procumbens.*

The density and dry weight of weeds were significantly reduced by all weed management practices over the weedy check (Table 1). The maximum and minimum density and dry weight of weeds were recorded with weedy check (T_1) and farmer's practice (T_{11}), respectively. Among the weed management practices, weed density and dry weight recorded with pre-emergence application of pendimethalin @ 1.5 kg a.i ha^{-1}fb. Interculture at 40 DAS (T_4), pre-emergence application of pendimethalin @ 1.5 kg a.i ha^{-1}fb.

Table 3. Economics of cotton as influenced by sequential application of herbicides.

Treatments	Seed cotton Yield (kg ha^{-1})	Gross Returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net Returns (Rs. ha^{-1})	Benefit cost ratio (BCR)
T_1: Weedy Check	1422	61017	31314	28410	0.91
T_2: Hand weeding twice at 30 and 60 DAS	2652	113212	55854	55530	0.99
T_3: Pendimethalin @ 1.5 kg a.i ha^{-1} as PRE	2136	91352	39076	50636	1.30
T_4: Pendimethalin @ 1.5 kg a.i ha^{-1} fb. interculture at 40 DAS	2437	104017	42984	59370	1.38
T_5: Pendimethalin @ 1.5 kg a.i ha^{-1} fb. fenoxaprop ethyl @ 56 g a.i ha^{-1} at 40 DAS	2140	91327	40304	49576	1.23
T_6: Pendimethalin @ 1.5 kg a.i ha^{-1} fb. quizalofop ethyl @ 50 g a.i ha^{-1} at 40 DAS	2034	86875	40310	45118	1.12
T_7: Pendimethalin @ 1.5 kg a.i ha^{-1} fb. pyrithiobac @ 63 g a.i ha^{-1} at 40 DAS	2380	101616	43058	56902	1.32
T_8: Interculture at 20 DAS fb. fenoxaprop ethyl @ 56 g a.i ha^{-1} at 40 DAS	2124	90636	39626	49582	1.25
T_9: Interculture at 20 DAS fb. quizalofop ethyl @ 50 g a.i ha^{-1} at 40 DAS	2150	91747	40688	49612	1.22
T_{10}: Interculture at 20 DAS fb. pyrithiobac @ 63 g a.i ha^{-1} at 40 DAS	2468	105301	43212	60444	1.40
T_{11}: Farmer's Practice	3252	138694	51954	84630	1.63
SEm $\pm$	137.3				
CD (p=0.05)	405.2				
CV %	10.4				

post-emergence application of pyrithiobac @ 63 g a.i ha^{-1} at 40 DAS (T_7) and Interculture at 20 DAS fb. pyrithiobac @ 63 g a.i ha^{-1} at 40 DAS (T_{10}) were comparable with that of hand weeding twice at 30 and 60 DAS (T_2). This might be due to effective control of early emerged weeds with pre-emergence application of pendimethalin or intercultural operations and the late emerged flushes of weeds were effectively controlled by post-emergence herbicides or intercultural operations.

Higher weed control efficiency of 86.7 per cent was recorded with farmer's practice (T_{11}) which was on a par with hand weeding twice at 30 and 60 DAS (75.1 %). Among the weed management practices, weed control efficiency recorded with pendimethalin @ 1.5 kg a.i ha^{-1} fb. interculture at 40 DAS (62.3%), pendimethalin @ 1.5 kg a.i ha^{-1} fb. pyrithiobac @ 63 g a.i ha^{-1} at 40 DAS (56.6 %) and interculture at 20 DAS fb. pyrithiobac @ 63 g a.i ha^{-1} at 40 DAS (52.4 %) were on a par with each other. This might be due to effective control of broad leaved weeds with integration of interculture either with pendimethalin or pyrithiobac and sequential application of pendimethalin as pre-emergence and post-emergence application of pyrithiobac combination. These results were in conformity with the findings of Panwar *et al*. (2001) and Toler *et al.* (2002).

Plant height was significantly influenced by various weed management practices in cotton (Table 2). The maximum plant height was recorded with farmer's practice (T_{11}) which was markedly higher than the plant height observed with hand weeding twice at 30 and 60 DAS (T_2). Among the weed management practices, plant height observed with T_3, T_4, T_7, T_8, T_9 and T_{10} treatments were comparable with hand weeding twice at 30 and 60 DAS (T_2). Number of monopodial branches per plant observed

with farmer's practicewas markedly higher than all other weed management practices studied. The number of monopodial branches per plant observed with T_3, T_4, T_5, T_6, T_7 T_8, T_9 to T_{10} were comparable with each other and markedly lower than T_2 and T_{11} but higher than the weedy check.

Highest number of sympodial branches and number of bolls per plant were recorded with farmer's practice whereas the lowest number with the weedy check (T_1). Among the weed management practices, sympodials and number of bolls per plant observed with T_4, T_7 and T_{10} treatments were comparable with hand weeding twice at 30 and 60 DAS (T_2) and markedly higher than the weedy check. Boll weight was found to be non significant across the weed management practices studied. The highest seed cotton yield of 3252 kg ha^{-1} was recorded with farmer's practice (Table 2). This was due to less density and dry weight of weeds leading to higher dry matter production of cotton plant with more number of sympodial branches, more number of bolls and resulting in higher seed cotton yield. Similar results were reported by Satao *et al.* (1998). Among the weed management practices, seed cotton yield recorded with T_4 (2437 kg ha^{-1}), T_7 (2380 kg ha^{-1}) and T_{10} (2468 kg ha^{-1}) treatments were comparable with hand weeding twice at 30 and 60 DAS (2652 kg ha^{-1}).

Weed index is the extent of yield reduction due to competition from weeds. Among the weed management practices, lowest weed index was recorded with hand weeding twice at 30 and 60 DAS (T_2) which was on a par with T_4, T_7 and T_{10} treatments. The highest weed index of 56.8 per cent was recorded with weedy check which might be due to higher dry matter accumulation of weeds, consequently, reduced seed cotton yield.

The maximum net returns and benefit cost ratio were recorded with farmer's practice (Rs. 84,630 ha^{-1} and 1.63) and minimum with the weedy check, Rs. 28,410 ha^{-1} and 0.91 (Table 3). This might be due to effective control of weeds which reflected in less weed population, dry weight of weeds and maximum number of bolls plant^{-1}, higher seed cotton yield and higher gross returns. The results were in agreement with the findings of Satao *et al.* (1998). Among the weed management practices, net returns and benefit cost ratio recorded with T_4, T_7 and T_{10} were higher than the T_2, even though it recorded the higher seed cotton yield and gross returns than the T_4, T_7 and T_{10} treatments, but incurred higher labour wages in performing the hand weeding twice at 30 and 60 DAS.

From this study, it is concluded that, in order to reduce the crop-weed competition in cotton during critical period, regular intercultural operations (gorru followed by guntaka) is found to be economical. Whenever, wet spells prevails during critical period especially in heavy soils (which does not permit intercultural operations), chemical control of weeds by application of selective post-emergence herbicide like pyrithiobac @ 63 g *a.i* ha^{-1} is recommended to control predominant broad leaved weeds in cotton. For ensured weed free situations during the critical period, sequential application of pre-emergence herbicide pendimethalin @ 1.5 kg *a.i* ha^{-1} followed by post-emergence application of pyrithiobac @ 63 g *a.i* ha^{-1} is more economical in reducing weed index thereby increasing seed cotton yield.

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