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Economics of integrated weed management practices in Rabi hybrid maize (*Zea mays*)

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Abstract
An experiment was conducted during *rabi* season of 2015-2016 at Agricultural College and Research Institute, Killikulam to study the effect of weed management on yield and economics of maize. Weed management has positive influence on growth, yield attributes and yield of maize. Maximum highest grain yield were recorded under alachlor @ 1.5 kg a.i ha^{-1} + HW on 30 DAS (T_2) (7115 kg ha^{-1}) and was statistically at par with grain yield obtained by two hand weedings on 15 and 30 DAS (T_{10}) (6855 kg ha^{-1}) and mechanical weeding with power weeder twice on 15 and 30 DAS (6714 kg ha^{-1}). The highest net returns and highest B:C ratio were obtained under alachlor @ 1.5 kg a.i ha^{-1} + HW at 30 DAS (T_2) followed by two hand weedings on 15 and 30 DAS (T_{10}). Alachlor @ 1.5 kg a.i ha^{-1} + HW at 30 DAS proved equally effective in increasing most of the growth parameters, yield attributes, yield and economic advantage.

Keywords: economics, integrated weed management, maize

Introduction
Maize is the world's third most important cereal crop after wheat and rice and is grown for grain and fodder. It is also known as "Queen of Cereals". Weeds are main hurdle in exploiting potential yield in *rabi* season. The competition from broad spectrum of weeds reduced yield of crop to a greater extent. The conventional methods of weed control are the age old practices to control weeds and these methods are slow, labour consuming and impractical during bad weather. Integrated weed management is preferable approach to minimize the crop-weed competition with reduced cost of weed management practices with minimum damage to environment. Therefore, the present study was planned to find out the effective and economic weed management practices in maize crop.

Materials and Methods
The field experiment was conducted during *rabi* season of 2015-2016 at Department of farm management, Agricultural College and Research Institute, Killikulam. The experimental field is geographically located in the southern part of Tamil Nadu at 8°46' North latitude and 77° 42' East longitude at an altitude of 40 meters above mean sea level. The experimental site was sandy clay loam having 0.34% organic carbon, neutral in reaction (pH 7.28), low in available N (198 kg ha^{-1}), low in available P_2O_5 (10.1 kg ha^{-1}) and medium in available K_2O (139 kg ha^{-1}). The experiment was laid out in a Randomized Block Design with three replications. The gross plot size was 5 x 3.6 m and net plot size was 3.8 x 3.1 m. A set of twelve treatments *viz.*, T_1 - Alachlor @ 1.5 kg a.i ha^{-1}, T_2 - Alachlor @ 1.5 kg a.i ha^{-1} + one hand weeding on 30 DAS , T_3 - Alachlor @ 1.5 kg a.i ha^{-1} + one mechanical weeding with power weeder on 30 DAS , T_4 - Atrazine @ 0.25 kg a.i ha^{-1}, T_5 - Atrazine @ 0.25 kg a.i ha^{-1} + one hand weeding on 30 DAS, T_6 - Atrazine @ 0.25 kg a.i ha^{-1} + one mechanical weeding with power weeder on 30 DAS, T_7 - Pendimethalin @ 0.75 kg a.i ha^{-1}, T_8 - Pendimethalin @ 0.75 kg a.i ha^{-1} + one hand weeding on 30 DAS, T_9 - Pendimethalin @ 0.75 kg a.i ha^{-1} + one mechanical weeding with power weeder on 30 DAS, T_{10} - Hand weeding twice on 15 and 30 DAS, T_{11}- Mechanical weeding with power weeder twice on 15 and 30 DAS, T_{12} - Unweeded control. Hybrid maize COH (M) 6 was sown with a spacing of 60 x 25 cm. Crop was fertilized with 250:75:75 Kg NPK ha^{-1} through urea, single super phosphate and muriate of potash respectively. All the herbicides dissolved in water (500 L ha^{-1}) was sprayed as pre-emergence on the next day of sowing. Cost of cultivation and gross returns were calculated on the basis of prevailing market prices of different inputs and produces, respectively.

Results and Discussion

The predominant weeds in the experimental field were *Cyperus rotundus* among sedges, *Cynodon dactylon* among grasses and *Digera arvensis*, *Trianthema portulacastrum*, *Cleome viscosa* and *Phyllanthus niruri* among broad-leaved weeds. There was a reduction in the weed density and weed drymatter production due to various weed control treatments when compared with control.

Among all the treatments, alachlor @ 1.5 kg a.i ha^{-1} with one hand weeding on 30 DAS (T_2) was the most effective in controlling the weeds (WCE 90.33% at 20 DAS), followed by hand weeding twice on 15 and 30 DAS (T_{10}) (WCE 84.08% at 20 DAS) (Table 1). The initial weed population was effectively controlled by persistence activity of pre-emergence application of atrazine was registered. The results are in line with the findings of Malviya *et al.* (2012) [2] and Kamble *et al.* (2005) [1].

Grain yield was highest with alachlor @ 1.5 kg a.i ha^{-1} as pre-emergence with one hand weeding on 30 DAS (T_2) (7115 kg ha^{-1}), which was in parity with hand weeding twice on 15 and 30 DAS (T_{10}) (6855 kg ha^{-1}) (Table 1). This was due to lesser crop weed competition for growth resources throughout the crop growth period and availability of congenial environment for better expression of growth and yield potential. Similar findings were reported by Pandey *et al.*, (2001) [3], Sunitha *et al.*, (2011) [6] and Sandhya Rani and Karuna Sagar (2013) [5]. Heavy weed infestation in unweeded control (T_{12}) had deprived the crop for all the growth resources and resulted in poor performance of cob yield (Table 1).

From the technology recommendation and adaptation point of view, economic evaluation plays a paramount role as the yields produced by the various treatments show their benefits only when the production cost is lower and net return higher finally benefitting the growers. Among all the treatments, application of alachlor @ 1.5 kg a.i ha^{-1} as pre-emergence with one hand weeding on 30 DAS (T_2) fetched higher gross returns (₹.1,04,240 ha^{-1}). It was followed by hand weeding twice on 15 and 30 DAS (T_{10}) with a gross return of ₹ .1,00,410 ha^{-1}. The better gross returns could be attributed to the better weed control achieved in these treatments resulting in higher yield. The lowest gross returns of ₹.65,340 ha^{-1} was recorded in unweeded control (T_{12}) indicating the severe crop weed competition resulting in decreased the cob yield.

Highest net returns of ₹.62,256 ha^{-1} was recorded with the application of alachlor @ 1.5 kg a.i ha^{-1} with one hand weeding on 30 DAS (T_2). It was followed by hand weeding twice on 15 and 30 DAS (T_{10}) with ₹.57,578 ha^{-1} and mechanical weeding with power weeder twice on 15 and 30 DAS (T_{11}) with ₹.57,044 ha^{-1} was the next best treatments. The reason for the higher net return was due to higher gross returns and less cost of cultivation. The results are in conformity with findings of (Porwal, 2000) [4].

Among all the treatments, application of alachlor @ 1.5 kg a.i ha^{-1} with one hand weeding on 30 DAS (T_2) fetched higher B:C ratio of 2.48. It was followed by mechanical weeding with power weeder twice on 15 and 30 DAS (T_{11}) with a B:C ratio of 2.38 (Table 2). From the above results it could be inferred that application of alachlor @ 1.5 kg a.i ha^{-1} with one hand weeding on 30 DAS (T_2) to maize was found to be better in terms of weed control, yield and lesser cost of cultivation making it a desirable treatment for the farmers.

Table 1: Weed density, weed control efficiency and grain yield of hybrid maize as influenced by different weed control treatments

	Treatments	Weed density (No. m^{-2})		Weed Control Efficiency (%)		Grain yield (kg ha^{-1})	
		20 DAS	40 DAS	20 DAS	40 DAS		
T_1	Alachlor @ 1.5 kg a.i ha^{-1} (PE)	36.48 (6.08)	42.61 (6.57)	80.48	73.12	6431	
T_2	Alachlor @ 1.5 kg a.i ha^{-1} + one hand weeding on 30 DAS	20.19 (4.55)	31.46 (5.65)	90.33	89.41	7115	
T_3	Alachlor @ 1.5 kg a.i ha^{-1} + one mechanical weeding with power weeder on 30 DAS	31.58 (5.66)	27.24 (5.27)	82.79	74.53	6584	
T_4	Atrazine @ 0.25 kg a.i ha^{-1} (PE)	41.84 (6.51)	46.58 (6.86)	69.65	61.20	5959	
T_5	Atrazine @ 0.25 kg a.i ha^{-1}+ one hand weeding on30 DAS	30.91 (5.60)	24.41 (4.99)	73.71	66.77	6218	
T_6	Atrazine @ 0.25 kg a.i ha^{-1}+ one mechanical weeding with power weeder on 30 DAS	33.26 (5.81)	28.97 (5.43)	71.69	63.15	6053	
T_7	Pendimethalin @ 0.75 kg a.i ha^{-1} (PE)	44.81 (6.73)	49.64 (7.08)	64.89	50.89	5581	
T_8	Pendimethalin @ 0.75 kg a.i ha^{-1} + one hand weeding on 30 DAS	33.32 (5.82)	24.78 (5.03)	66.34	55.57	5793	
T_9	Pendimethalin @ 0.75 kg a.i ha^{-1} + one mechanical weeding with power weeder on 30 DAS	39.71 (6.34)	28.54 (5.39)	63.55	52.36	5711	
T_{10}	Hand weeding twice on 15 and 30 DAS	27.26 (5.27)	20.87 (4.62)	84.08	77.53	6855	
T_{11}	Mechanical weeding with power weeder twice on 15 and 30 DAS	32.82 (5.77)	44.36 (6.70)	83.59	76.19	6714	
T_{12}	Unweeded control	98.49 (9.95)	134.35 (11.61)	-	-	4967	
	SEd	0.48	0.34			162	
	CD (P=0.05)	1.00	0.70			335	

The figures in the parenthesis indicate transformed values ($\sqrt{x+0.5}$)

Table 2: Economics of different weed control treatments in hybrid maize

	Treatments	Cost of cultivation	Gross return	Net return	B: C ratio
T_1	Alachlor @ 1.5 kg a.i ha^{-1}	40297	94260	53963	2.34
T_2	Alachlor @ 1.5 kg a.i ha^{-1} + one hand weeding on 30 DAS	41984	104240	62256	2.48
T_3	Alachlor @ 1.5 kg a.i ha^{-1} + one mechanical weeding with power weeder on 30 DAS	40860	96475	55615	2.36
T_4	Atrazine @ 0.25 kg a.i ha^{-1}	39136	87370	48234	2.23
T_5	Atrazine @ 0.25 kg a.i ha^{-1} + one hand weeding on 30 DAS	41384	91160	49776	2.20
T_6	Atrazine @ 0.25 kg a.i ha^{-1} + one mechanical weeding with power weeder on 30 DAS	40260	88700	48440	2.20
T_7	Pendimethalin @ 0.75 kg a.i ha^{-1}	39036	78820	39784	2.01
T_8	Pendimethalin @ 0.75 kg a.i ha^{-1} + one hand weeding on 30 DAS	41284	86900	45616	2.10
T_9	Pendimethalin @ 0.75 kg a.i ha^{-1} + one mechanical weeding with power weeder on 30 DAS	38936	83700	44764	2.15
T_{10}	Hand weeding twice on 15 and 30 DAS	42832	100410	57578	2.34
T_{11}	Mechanical weeding with power weeder twice on 15 and 30 DAS	41336	98380	57044	2.38
T_{12}	Unweeded control	38336	65340	27004	1.70

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