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Effect of sustainable weed management practices on weed growth and productivity of maize

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Abstract
Field experiments were conducted in Agricultural College and Research Institute, Madurai, Tamil Nadu Agricultural University during *Rabi* season of 2013. The experimental soil was clay loam of Madukur Series with neutral pH. The experiments were laid out in split plot design with three replications. The main plots were consisted with cropping system, *viz*. maize, maize + blackgram, maize + cowpea and weed management practices such as pre emergence (PE) application of pendimethalin at 0.75 kg/ha, alachlor at 1 kg/ha and oxyfluorfen at 0.2 kg/ha and in combination with one rotary hoeing on 35 DAS. In addition to this, rotary hoeing twice at 15 and 35 DAS, hand weeding on 15, 35 DAS and unweeded check were assigned to sub plots. The experimental results revealed that weed population and weed DMP were higher in sole maize cropping than intercropping situation. The maize + cowpea system resulted higher weed control cum smothering efficiency (74.40) than maize + blackgram system (73.66). Maize + cowpea system influences the higher yield attributes like cob length (16.83 cm), cob girth (14.47 cm), number of grains per cob (490.67), test weight (34.06 g). The application of pendimethalin at 0.75 kg/ha + rotary hoeing on 35 DAS has produced higher yield attributes and grain yield of maize 6051 kg/ha.

Keywords: maize yield, intercropping systems, herbicides, rotary hoeing, hand weeding.

Introduction
Maize is the most important component of food security at global level. In India, maize is the third most important food crop after rice and wheat with an area of 168.2 million hectares with a production of 854.5 million tonnes with average productivity of 5.12 t/ha. Maize is known for its yield potential. It is being a rainy season and widely spaced crop, gets infested with variety of weeds and subjected to heavy weed competition, which often inflicts huge losses ranging from 28-100% (Patel *et al*., 2006) [8]. Weeds emerge fast and grow rapidly competing with the maize crop severely for nutrients, moisture, sunlight and space during initial stages of crop growth. Further, wide space provided to the maize allows fast growth of variety of weed species, causing considerable reduction in yield by affecting the growth, yield and yield components. Space available to the individual plant is necessary to use the soil resources effectively and to harvest the maximum possible solar radiation to attain higher yield. Natural resources viz., space, light, nutrients, moisture are underutilized. Such natural resources could effectively be used by introducing pulse crop like blackgram and cowpea as intercropping which complete their life cycle shortly and would not compete much with corn. However, the productivity of the maize crop is limited by a number of biotic and abiotic factors out of which weed infestation is the most limiting factor causing the yield loss to the crop. Since labour is costly and scarce, timely weeding is not possible and this becomes major bottle neck in its production. The maximum weed competition in maize occurs during the period of 2-6 weeks after sowing. There are very few herbicide options available for weed control in maize in India, so use of pre emergence herbicides in combination with cultural practices found to be better choice (Ishrat 2012) [5]. Keeping all these aspects in view, an attempt was made to find out sustainable weed management practices for broad spectrum weed control in maize.

Materials and Methods
A field experiment was conducted during *Rabi* 2013 at Agricultural College and Research Institute, Madurai. The experimental site is situated at 9°54' N latitude and 78°54' 'E' longitude at an altitude of 147m above MSL.

The soil of the experimental field was well drained clay loam of Madukur Series with neutral pH of 7.2; low in organic carbon (0.32%) and available N (242.4 kg ha^{-1}), medium in available P (16.5 kg ha^{-1}) and medium in available K (235.8 kg ha^{-1}). Test crops are maize hybrid, black gram and cowpea with varieties of '*COHM 6*', '*VBN (Bg) 4*' and '*VBN1*', respectively. The experiment was carried out in split plot design with three replications. The main plots were assigned with cropping system, *viz*. maize, maize + blackgram, maize + cowpea and weed management practices such as pre emergence (PE) application of pendimethalin at 0.75 kg/ha, alachlor at 1 kg/ha and oxyfluorfen at 0.2 kg/ha and in combination with one rotary hoeing on 35 DAS. In addition to this, rotary hoeing twice at 15 and 35 DAS, hand weeding on 15, 35 DAS and unweeded check were assigned to sub plots. The recommended fertilizer schedule of 250:75:75 kg NPK ha^{-1} was applied in maize crop. The entire quantity of P and K and 50 per cent of N were applied as basal in the sowing lines of maize. The remaining quantity of nitrogen was applied as two equal splits on 30 and 45 DAS. The weed count was taken at 15, 35 and 60 DAS. The weed count was recorded group-wise viz., grasses, sedges and broad leaved weed using 0.25 m^2 quadrat from four randomly selected fixed places in each plot and expressed in Number m^{-2} as suggested by Burnside and Wicks 1965 [1]. Weeds found within two 0.50 m^{-2} quadrat were removed, sun dried and then oven dried at 70 ^{0}C for 72 hours. The dry weight of the weeds were assessed and expressed in kg ha^{-1}. From this weed control cum smothering efficiency was calculated as suggested by Mahendran (1994) [6] and expressed in percentage.

$$\text{WCSE} = \frac{\text{(Weed DMP in control cum sole – (Weed DMP in weed management cum crop in kg ha}^{-1}\text{) smothering intercrop in kg ha}^{-1}\text{)}}{\text{Weed DMP in control cum sole crop, (kg ha}^{-1}\text{)}} \times 100$$

Harvested cobs from the net plot were weighed and expressed in kg ha^{-1}. The data observed were subjected to statistical analysis for testing significance.

Results and Discussion

Effect of sustainable weed management practices on weeds density

In general, weed population and weed DMP was higher during *kharif* season. The intercropping in maize exerted significant influence on reducing the total weed population at 15, 35 and 60 DAS. Velayutham *et al*., (2002) [9] suggested that intercrops provide efficient coverage of land resulting in suppression of weed growth. Among the intercropping system, maize + cowpea reduced the weed density to a higher level (35.82, 36.56 and 58.16) on 15, 35 and 60 DAS followed by maize + blackgram system (Table 1). The application of pre-emergence herbicides combined with one rotary hoeing reduced the total weed population at all stages of observation. The reduction in weed density in intercropping systems may be attributed to shading effect and competition stress created by the canopy of more crops in a unit area having suppressive effect on associated weeds, thus preventing the weeds to attain full growth. Such reduction in weed density under intercropping was more pronounced with reference to sedges and grasses rather than broad leaved weeds (Pandey *et al.*, 2003) [7].

Effect of sustainable weed management practices on weed drymatter production

Intercropping systems had shown adverse effect on weed DMP than sole maize. With regard to weed DMP, intercropping systems reduced the weed DMP due to lesser weed population. Intercropping treatments recorded lesser number of weeds and weed DMP when compared to sole maize. Haque *et al*., (2013) [4] revealed that complete coverage and high plant density available in intercropping system which caused severe competition with the weeds and reduced the weed growth. The application of pendimethalin @ 0.75 kg ha^{-1} with one rotary hoeing recorded lesser dry matter production of weeds which was followed by alachlor @ 1.0 kg ha^{-1} with one rotary hoeing and oxyfluorfen @ 0.2 kg ha^{-1} with one rotary hoeing (Table 2). This might be due to effective control of weed seed germination in the early stages of crop growth (Chalka and Nepalia 2006) [2].

Effect of sustainable weed management practices on weed control cum smothering efficiency

Intercropping and weed control treatments appreciably influenced the weed control cum smothering efficiency. Maize + cowpea intercropping system registered the highest weed control cum smothering efficiency value of 58.48, 59.34 and 74.40 percent on 15, 35 and 60 DAS. Pre-emergence application of pendimethalin @ 0.75 kg ha^{-1} + one rotary hoeing (W_1) recorded the higher WCSE of 59.30, 58.48 and 59.55 percent on 15, 35 and 60 DAS (Table 3). It might be due to shading effect and competition stress created by the canopy of more crops in a unit area having suppressive effect on associated weeds, thus preventing the weeds to attain full growth (Dwivedi *et al.,* 2012) [3].

Effect of sustainable weed management practices on productivity of maize

Maize + cowpea intercropping system registered higher yield parameters viz., cob length, cob girth, number of grains per cob and test weight. This might be due to the complementary effect of cowpea which favoured the source-sink relation in maize and produced better yield components resulted in higher maize grain yield (Chalka and Nepalia, 2006) [2].The increased grain yield was registered with the application of pendimethalin @ 0.75 kg ha^{-1} as pre-emergence fb one rotary hoeing. This was followed by pre-emergence application of alachlor @ 1.0 kg ha^{-1} with one rotary hoeing (Table 4). This might be due to better control of all categories of weeds. In addition to that, lower nutrient depletion and lesser DMP of weeds and thereby increasing the nutrient uptake by crop influenced the growth and yield attributes which favoured grain yield of maize (Walia *et al*., 2007) [10].

Table 1: Total weed population as influenced by sustainable weed management practices (No.m^{-2})

Treatments	15 DAS	35 DAS	60 DAS
Cropping system			
C_1- Maize alone	(49.93) 7.07	(56.31) 7.50	(89.09) 9.44
C_2- Maize + Blackgram	(41.89) 6.47	(44.50) 6.67	(70.29) 8.38

C_3- Maize + Cowpea	(35.82) 5.98	(36.56) 6.05	(58.16) 7.63
SEd	0.54	0.79	1.19
CD (P=0.05)	1.52	2.21	3.30
Weed control treatments			
W_1-PE Pendimethalin + one Rotary hoeing	(21.06) 4.59	(21.50) 4.64	(42.41) 6.51
W_2- PE Alachlor + one Rotary hoeing	(27.56) 5.25	(31.28) 5.59	(56.89) 7.54
W_3- PE Oxyfluorfen + one Rotary hoeing	(33.69) 5.80	(37.69) 6.14	(70.89) 8.42
W_4- Rotary hoeing twice (15 & 35 DAS)	(38.81) 6.23	(41.05) 6.41	(78.34) 8.85
W_5- Hand weeding twice (15 & 35 DAS)	(45.58) 6.75	(45.61) 6.75	(78.83) 8.88
W_6- Unweeded check	(84.83) 9.21	(101.33) 10.07	(136.56) 11.69
SEd	0.95	0.99	1.82
CD (P=0.05)	1.94	2.03	3.73
C at W			
SEd	1.60	1.76	3.12
CD (P=0.05)	3.41	3.87	6.71

Figures in the paranthesis are original values. Others are square root transformed [SQR (X+0.5)] values.

Table 2: Weed DMP as influenced by sustainable weed management practices (kg ha^{-1})

Treatments	**15 DAS**	**35 DAS**	**60 DAS**
Cropping system			
C_1- Maize alone	(223.62) 14.17	(228.57) 14.31	(255.43) 14.96
C_2- Maize + Blackgram	(179.93) 12.48	(182.63) 12.50	(194.51) 12.83
C_3- Maize + Cowpea	(155.65) 11.67	(155.37) 11.63	(189.04) 12.61
SEd	0.22	0.24	0.24
CD (P=0.05)	0.60	0.66	0.67
Weed control treatments			
W_1-PE Pendimethalin + one Rotary hoeing	(51.23) 7.08	(57.42) 7.45	(92.62) 9.52
W_2- PE Alachlor + one Rotary hoeing	(72.13) 8.42	(69.50) 8.16	(103.57) 10.08
W_3- PE Oxyfluorfen + one Rotary hoeing	(79.63) 8.87	(78.00) 8.74	(120.67) 10.90
W_4- Rotary hoeing twice (15 & 35 DAS)	(290.53) 16.99	(291.28) 16.98	(148.39) 12.13
W_5- Hand weeding twice (15 & 35 DAS)	(302.50) 17.35	(302.49) 17.32	(164.00) 12.72
W_6- Unweeded check	(322.37) 17.92	(334.45) 18.26	(648.70) 25.44
SEd	0.17	0.52	0.37
CD (P=0.05)	0.36	1.07	0.77
C at W			
SEd	0.35	0.86	0.64
CD (P=0.05)	0.81	NS	NS

Figures in the paranthesis are original values. Others are square root transformed [SQR (X+0.5)] values.

Table 3: Weed control cum smothering efficiency (WCSE) as influenced by sustainable weed management practices (%)

Treatments	**Weed control cum smothering efficiency (WCSE)**		
Cropping system	**15 DAS**	**35 DAS**	**60 DAS**
C_1- Maize alone	-	-	-
C_2- Maize + Blackgram	52.00	52.21	73.66
C_3- Maize + Cowpea	58.48	59.34	74.40
Weed control treatments			
W_1-PE Pendimethalin + one Rotary hoeing	59.30	58.48	59.55
W_2- PE Alachlor + one Rotary hoeing	56.04	57.21	58.63
W_3- PE Oxyfluorfen + one Rotary hoeing	54.53	54.89	57.23
W_4- Rotary hoeing twice (15 & 35 DAS)	18.69	20.12	54.74
W_5- Hand weeding twice (15 & 35 DAS)	18.40	19.92	53.82
W_6- Unweeded check	-	-	-

Data not statistically analyzed

Table 4: Yield and yield parameters of maize as influenced by sustainable weed management practices in maize

Treatments	Cob length (cm)	Cob girth (cm)	Number of grains cob^{-1}	Test weight (g)	Grain yield Kg/ha
Cropping system					
C_1- Maize alone	13.75	12.77	442.44	30.17	3312
C_2- Maize + Blackgram	15.53	13.11	463.56	31.89	3922
C_3- Maize + Cowpea	16.83	14.47	490.67	34.06	4938
SEd	0.50	0.49	12.92	1.05	133.50
CD (P=0.05)	1.38	1.35	35.86	2.91	370.67
Weed control treatments					
W_1-PE Pendimethalin + one Rotary hoeing	19.11	15.72	558.00	36.67	6051
W_2-PE Alachlor + one Rotary hoeing	17.17	14.22	530.78	33.56	5225
W_3-PE Oxyfluorfen + one Rotary hoeing	16.00	13.78	506.00	32.44	4359
W_4-Rotary hoeing twice (15 & 35 DAS)	15.06	12.39	481.56	31.33	3428
W_5- Hand weeding twice (15 & 35 DAS)	13.00	13.37	401.56	30.33	3090
W_6- Unweeded check	11.89	11.23	315.44	27.89	2194
SEd	0.70	0.64	14.23	0.92	255.90
CD (P=0.05)	1.43	1.31	29.07	1.88	522.62
C at W					
SEd	1.21	1.12	25.95	1.79	426.07
CD (P=0.05)	NS	NS	NS	NS	900.87

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