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Influence of weed management practices in maize (*Zea mays*) based intercropping system

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ABSTRACT

A field experiment was conducted at University of Agricultural Sciences, Bengaluru during *kharif* 2016 and 2017 on red sandy loam soil and the experiment was laid out in Randomized Complete Block Design with factorial concept and replicated thrice. There were 15 treatment combinations involving three intercrops and five weed management practices. The results of the experiment revealed that intercropping of maize (*Zea mays* L.) with cowpea [*Vigna unguiculata* (L.) Walp.] has recorded significantly lower total weed density (5.92 No./m^2), weed dry weight (6.21 g/m^2), higher WCE (66.97 %), lower WI (17.67 %), higher grain yield (5842 kg/ha) and stover yield (7035 kg/ha) but the higher MEY (8224 kg/ha) was recorded in maize + pole bean intercropping system. Among the different weed management practices, pre-emergence application of pendimethalin 30 % EC @ 1.50 kg/ha recorded significantly lower weed population (5.12 No./m^2), weed dry weight (5.05 g/m^2), higher WCE (81.81 %), lower WI (7.24 %), higher grain (6589 kg/ha), stover yield (8033 kg/ha) and MEY (8860 kg/ha) compared to other weed management practices.

Keywords: Intercrops, Maize, MEY, WCE, Weed index

Maize (*Zea mays* L.) being an important cereal crop globally next to wheat and rice is called 'Queen of Cereals' due to its higher genetic yield potential. In India, maize is cultivated in an area of 9.4 m ha with production of 22.27 mt. However, its productivity is 2.5 t/ha which is much lower than the global average. The low productivity of maize in India as compared to world productivity can be attributed to several limiting factors and most important amongst these has been the poor weed management which poses a major threat to crop productivity. Of the total estimated losses caused in production by pests, insects, diseases and weeds in the world, weeds alone responsible for one-third of it. On the other hand high cost involved in manual weeding, dearth of labours, when really are on demand and at times no soil workable condition due to incessant rains makes it imperative to opt herbicidal control of weeds particularly in row crops.

Under the situation referred above the concept of intercropping offers ample scope for combating weeds (Willey, 1979) without any threat to ecological degradation. Intercropping especially cereal + legume combination can increase production and productivity by better utilization of resources and thereby minimizes the risks and brings stability under rainfed conditions. Even if some weeds emerges in spite of growing intercrops, the quantum and frequency of herbicide used will be much lower than those recommended in their crops of pure stand. Hence, intercropping may either eliminates the use of herbicides or at least reduces their use considerably.Weed management research in India has been mainly confined to sole cropping and the information relating to weed control in intercropping system is rather meagre. So there is strong need of research on weed management in intercropping system taking pulses as a component crop to meet the demand of cereals and pulses to provide balance diet for achieving food and nutritional security of the nation. Keeping these things in the view present experiment on influence of weed management practices in maize based intercropping system was undertaken.

MATERIALS AND METHODS

The field experiment was conducted at Agro-forestry Research Unit, University of Agricultural Sciences, Bengaluru during *kharif* 2016 and 2017. The trial was experimented in Randomized Complete Block Design with three replications and factorial concept. A total of 15 treatment combinations involving three intercrops (I_1: Cowpea [*Vigna unguiculata* (L.) Walp.], I_2: Field bean, I_3: Pole bean) and five weed management practices (W_1:

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Pendimethalin @ 1.5 kg a.i./ha as pre-emergence (PE) spray; W_2: Alachlor @ 1.5 kg a.i./ha as PE spray; W_3: Two hand weedings at 15 + 30 DAS; W_4: Oxyflurofen @ 0.1 kg a.i./ha as PE spray; W_5: Unweeded check) were taken.

Weed population and weed dry weight: The weed population count of grasses, sedges and broad leaved weeds were recorded at different growth stages from 0.5 m × 0.5 m quadrant marked permanently in gross plot area and it was converted to square meter. For weed dry weight, samples were then removed and dried in oven at 60^0C and recorded the dry weight after the attainment of the constant weight and expressed in grams/m^2. The original data was transformed using square root transformation and analyzed statistically.

Table 1 Weed population and weed dry weight as influenced by intercrops and weed management practices in maize based intercropping system (Pooled data of 2 years)

Treatment	Weed population (No./m^2)		Weed dry weight (g/m^2)	
	30 DAS	60 DAS	30 DAS	60 DAS
Intercrops (I)				
I_1	5.92 (39.06)	8.28 (75.47)	6.21 (45.81)	9.18 (97.63)
I_2	6.04 (40.03)	8.39 (76.50)	6.38 (48.29)	9.37 (100.81)
I_3	6.67 (46.56)	9.05 (87.70)	7.06 (57.87)	10.19 (118.48)
SEm±	0.06	0.08	0.08	0.09
CD (P=0.05)	0.19	0.25	0.23	0.27
Weed management practices (W)				
W_1	5.12 (25.94)	7.28 (52.83)	5.05 (25.25)	7.53 (56.59)
W_2	5.51 (30.16)	7.70 (59.50)	5.42 (29.11)	8.01 (63.85)
W_3	4.14 (17.39)	5.70 (34.11)	3.70 (13.33)	5.88 (35.00)
W_4	6.54 (42.44)	8.91 (79.05)	6.81 (46.95)	9.99 (100.46)
W_5	9.67 (93.00)	13.20 (174.44)	11.78 (138.7)	16.49 (272.29)
SEm±	0.09	0.10	0.10	0.17
CD (P=0.05)	0.27	0.29	0.29	0.35
Interaction (I×W)				
T_1: I_1W_1	4.76 (22.16)	6.88 (46.83)	4.72 (21.89)	7.07 (49.66)
T_2: I_1W_2	5.14 (26.00)	7.33 (53.33)	5.09 (25.45)	7.62 (57.58)
T_3: I_1W_3	3.73 (14.16)	5.38 (30.33)	3.52 (11.96)	5.55 (31.42)
T_4: I_1W_4	6.38 (40.50)	8.81 (77.33)	6.38 (41.53)	9.64 (93.51)
T_5: I_1W_5	9.63 (92.50)	13.03 (169.50)	22.69 (128.4)	16.01 (256.00)
T_6: I_2W_1	4.86 (23.17)	7.06 (49.50)	4.91 (23.61)	7.40 (54.42)
T_7: I_2W_2	5.37 (28.50)	7.57 (56.83)	5.26 (27.21)	7.81 (60.57)
T_8: I_2W_3	3.95 (15.66)	5.61 (32.33)	3.49 (11.75)	5.81 (33.91)
T_9: I_2W_4	6.47 (41.50)	8.67 (74.83)	6.66 (44.63)	9.70 (94.53)
T_{10}:I_2W_5	9.54 (91.33)	13.05 (170.50)	11.60 (134.2)	16.15 (260.64)
T_{11}:I_3W_1	5.74 (32.50)	7.91 (62.17)	5.53 (30.26)	8.12 (65.67)
T_{12}:I_3W_2	6.04 (36.0)	8.29 (68.33)	5.92 (34.66)	8.59 (73.41)
T_{13}:I_3W_3	4.74 (27.00)	6.27 (39.66)	4.09 (16.30)	6.28 (39.71)
T_{14}:I_3W_4	6.76 (45.00)	9.24 (85.00)	7.38 (54.64)	10.63 (113.35)
T_{15}:I_3W_5	9.83 (96.67)	13.53 (183.33)	12.39 (153.5)	17.33 (300.24)
SEm±	0.15	0.20	0.18	0.20
CD (P=0.05)	NS	NS	NS	NS

Values in the parenthesis are original values. I_1: Cowpea; I_2: Fieldbean; I_3: Polebean; W_1: Pendimethalin 30 % EC @ 1.5 kg ai/ha as PE spray; W_2: Alachlor 50 % EC @ 1.5 kg ai/ha as PE spray; W_3: Two hand weedings at 15 and 30 DAS; W_4: Oxyflurofen 23.5 % @ 0.1 kg ai/ha as PE spray; W_5: Unweeded check.

Weed control efficiency (WCE): *WCE* was calculated as (Patel *et al.* 1987):

$$WCE = \frac{DMC - DMC}{DMC} \times 100$$

where, WCE = Weed control efficiency; DMC = Dry matter of weeds in weedy check plot; DMT = Dry matter of weeds in treated plots.

Weed index (WI): Weed index was calculated as (Gill and Vijaya Kumar 1969):

$$\text{Weed index (\%)} = \frac{X - Y}{X} \times 100$$

where, X= Grain yield of weed free plot; Y= Grain yield from treatment plot.

Maize equivalent yield (kg/ha): MEY of intercropping system was assessed as:

$$\text{MEY (kg/ha)} = \frac{\text{Yield of intercrop(kg/ha)} \times \text{Price of intercrop (₹/kg)}}{\text{Market price of maize (₹/kg)}} + \text{Yield of maize in intercropping system (kg/ha)}$$

Statistical analysis: The data were analyzed as per the standard procedure for analysis of variance as described by Gomez and Gomez (1984). The significance level of P=0.05 was adopted in 'F' and't' tests. In case the F test was found significant, the critical difference values were calculated for the interpretation of experimental results.

RESULTS AND DISCUSSION

Weed population: Intercropping of maize with cowpea recorded significantly lower total weed population (Table 1) at 30 DAS (5.92 No./m^2) and 60 DAS (8.28 No./m^2) as compared to maize + pole bean intercropping system (6.67 and 9.05 No./m^2, respectively). However, it was at par with maize + field bean intercropping (6.04 and 8.39 No./m^2, respectively). All the treatments of weed control recorded significantly lower population of weeds as compared to weedy check at 30 and 60 DAS (Table 1). Weed free check, which received hand weeding at 15 and 30 DAS indicated comparatively higher weed control compared to weed control through herbicides. However, this will be neither cost effective nor feasible where, the scarcity of labour prevails. The reduction in weed density and dry weight in maize + cowpea intercropping system (Table 1) may be attributed to competition stress and shading effect created by the crop canopy in a unit area which has suppressive effect on the associated weeds, thus preventing the weeds to achieve full growth (Pandey *et al.* 2003). Among the chemical weed control treatments, PE application of pendimethalin 30% EC @ 1.50 kg/ha has recorded significantly lower weed population (Table 1) at 30 DAS (5.12 No./m^2) and 60 DAS (7.28 No./m^2). This was mainly due to the effective control of weeds and reduction in the crop weed competition that ultimately improved growth. These findings are in close similarity with the findings of Singh *et al.* (2004) and Prasad *et al.* (2008).

Dry weight of weeds: Weed dry weight is an important parameter to assess the competitiveness of weeds for the crop growth and productivity. Intercropping of maize with cowpea recorded (Table 1) significantly lower total weed dry weight of grasses, broad leaved weeds and sedges at 30 DAS (6.21 g/m^2) and 60 DAS (9.18 g/m^2) as compared to maize + pole bean intercropping system (7.06 and 10.19 g/m^2, respectively). Total weed dry weight (g/m^2) varies significantly due to the various weed control treatments (Table 1). Over the period of crop growth, higher total weed dry weight was noted in weedy check (11.78 and 16.49 g/m^2 at 30 and 60 DAS, respectively). It was mainly due to enhanced and uninterrupted growth and development of weeds which enabled the best use of the growth resources. Among the herbicide treatments, pendimethalin 30 % EC @ 1.50 kg/ha was effective in reducing total dry weight (Table 1) of weeds at 30 DAS (5.05 g/m^2) and 60 DAS (7.53 g/m^2). Lower weed dry weight in pendimethalin might have inhibited the cell division and elongation of roots and shoots resulting in death of weed seedlings immediately after germination. These results are in conformity with the findings of Singh *et al.* (2004) and Praveen and Murthy (2005).

Weed control efficiency and weed index: Crop performance is directly proportional to the weed control efficiency and indirectly proportional to the weed index. In our study, higher WCE was recorded in maize + cowpea intercropping system (Fig 1) at 30 DAS (66.97%), 60 DAS (64.14%) and at harvest (35%). Among herbicides, pendimethalin 30 % EC @ 1.50 kg/ha as PE application recorded (Fig 1) higher weed control efficiency at 30 DAS

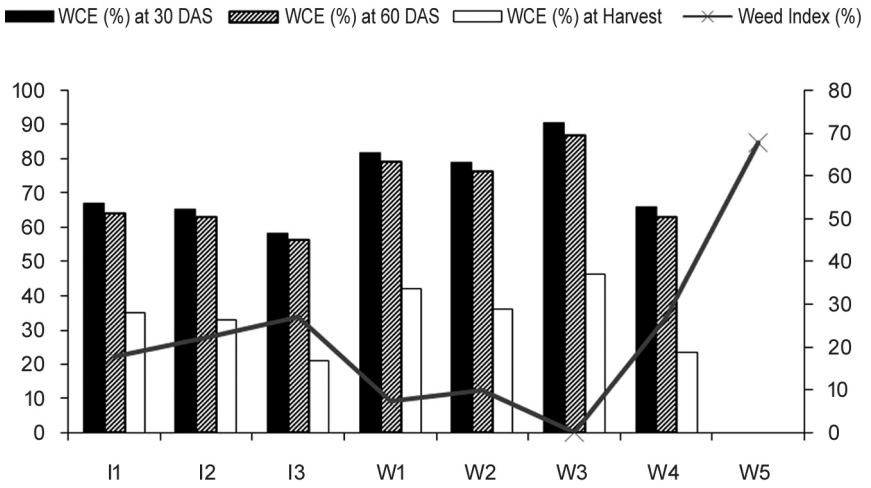

Fig 1 Weed control efficiency (%) and weed index as influenced by intercrops and weed management practices in maize based intercropping system. * Treatment details are given in the foot note of Table 1.

Table 2 Grain and stover yield and maize equivalent yield (MEY) as influenced by intercrops and weed management practices in maize based intercropping system (Pooled data of 2 years)

Treatment	Grain yield (kg/ha)	Stover yield (kg/ha)	MEY (kg/ha)
Intercrops (I)			
I_1	5842	7035	6915
I_2	5514	6730	6738
I_3	5186	6184	8224
SEm±	91.21	103.39	110.10
CD (P=0.05)	273.02	312.60	323.75
Weed management practices (W)			
W_1	6589	8033	8860
W_2	6393	7822	8353
W_3	7096	8162	9428
W_4	5205	6353	6626
W_5	2286	2877	3195
SEm±	219.53	225.60	141.54
CD (P=0.05)	655.10	657.10	418.20
Interaction (I×W)			
T_1: I_1W_1	6962	8332	8456
T_2: I_1W_2	6978	8401	8074
T_3: I_1W_3	7579	8860	9069
T_4: I_1W_4	5448	6709	6248
T_5: I_1W_5	2242	2872	2727
T_6: I_2W_1	6581	8341	8144
T_7: I_2W_2	6343	8062	7593
T_8: I_2W_3	7030	8180	8694
T_9: I_2W_4	5264	6176	6231
T_{10}:I_2W_5	2351	2887	3028
T_{11}:I_3W_1	6225	7425	9980
T_{12}:I_3W_2	5857	7003	9391
T_{13}:I_3W_3	6681	7447	10519
T_{14}:I_3W_4	4902	6173	7400
T_{15}:I_3W_5	2265	2872	3828
SEm±	210.24	391.56	245.67
CD (P=0.05)	NS	NS	NS

* Treatment details are given in the foot note of Table 1.

(81.81%), 60 DAS (79.22%) and at harvest (42.28%). Higher WCE and lower WI was recorded in maize + cowpea intercropping system might be ascribed to relatively less space available for the weed growth due to quick spread on ground and more shading effect (Mishra and Elamathi 2009).

Yield and yield attributes: Significantly higher grain yield (5842 kg/ha), stover yield (7035 kg/ha) was recorded in maize + cowpea intercropping system (Table 2). The higher yield could be due the complementary effect of cowpea which favoured the source-sink relation in maize and produced better yield components and yield (Chalka and Nepalia 2006). Among the weed control treatments, pendimethalin 30% EC @ 1.50 kg/ha recorded significantly higher grain and stover yield (6589 and 8033 kg/ha, respectively) as compared to weedy check (2286 and 2877 kg/ha, respectively). The superior yield in the treatment could be due to improved yield attributing parameters, viz. cob length, cob girth, kernel weight/cob, number of kernels/row, number of kernel rows/cob, number of kernels/cob and 100 kernel weight (Prasad *et al.* 2008).

Maize equivalent yield (MEY): Among the intercropping systems, significantly higher MEY was reported (Table 2) in maize + pole bean intercropping system (8224 kg/ha) followed by maize + cowpea (6915 kg/ha) and maize + field bean (6738 kg/ha) intercropping, which was attributed to higher yield and market price of pole bean. This could also be due to synergistic effect of maize and pole bean association which helps in efficient use of natural resources (Sannagoudar and Kalyana Murthy 2018). Among the weed control treatments, pendimethalin 30% EC @ 1.50 kg/ha noted significantly higher MEY (8860 kg/ha) as compared to other weed management practices. This improvement in yield might be due to improved growth parameters. Hence, the enhancement in crop growth and yield parameters was the owing to the lower crop weed competition, which altered the balance in favour of crop for the plant nutrition, moisture, light and space (Prasad *et al.* 2008).

From the experimental results, it could be concluded that, intercropping of maize + cowpea has noticed significantly higher grain and stover yield of maize as compared to maize + pole bean intercropping system. Pre-emergence application of pendimethalin 30% EC @ 1.5 kg a.i./ha recorded significantly higher grain yield, stover yield and MEY besides giving broad spectrum of weed control.

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