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Comparative Efficacy of Leguminous Intercrops and Weed Management Practices on Nutrient Uptake, Productivity and Profitability of Maize based Intercropping System

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ABSTRACT

Background: Presently, labour force is diminishing and becoming costlier. In agriculture management of weeds in cropped field has become a real challenge to the farmers, since weeds are affecting the crop yields due to competition for growth resources. Intercropping of leguminous crops and application of pre-emergence herbicides offers an ample scope for weed control.

Methods: The present study was conducted at University of Agricultural Sciences, Bengaluru during 2016 and 2017 on red sandy loam soil and the experiment was laid out in randomized complete block design (RCBD) with factorial concept and replicated thrice. There were 15 treatment combinations involving three intercrops and five weed management treatments.

Result: The results revealed that intercropping of maize with cowpea has recorded significantly higher grain yield (5842 kg/ha), stover yield (7035 kg/ha) and total nutrients uptake (99.53, 27.37, 96.95 kg/ha NPK, respectively). Among the chemical weed management practices, pre-emergence application of pendimethalin 30% EC @ 1.50 kg a.i./ha has recorded significantly higher grain (6589 kg/ha), stover yield (8033 kg/ha), maize equivalent yield (8860 kg/ha), total nutrients uptake (112.81, 31.05, 109.88 kg/ha NPK, respectively) and B:C ratio (3.35) compared to other weed management practices.

Key words: Economics, Intercrops, Maize, MEY, Nutrient uptake, Weed.

INTRODUCTION

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. A very congenial weather is experienced for growth and development of weeds after sowing of maize. Weed control is not only a ticklish problem, but also a costly one. Weeds take away major share of inherent and applied nutrients and pose severe competition to crop plants for space, solar radiation, carbon dioxide, moisture *etc*. Taking an inter crop is the best approach disallowing fast growth of weeds (Baumann *et al*., 2000). It is essential to select an intercrop having quick growth habit right from the seedling stage and maturing early, so that it is harvested before the grand growth period of the main crop. In this way the inter crop gives almost minimum competition to the main crop and is referred to as a parallel crop. When the growth of maize almost ceases, the weeds grow unabated. Under such circumstances, maize is ideally suited for adopting an intercropping system.

In the circumstances described above, the idea of intercropping provides enough opportunity to battle weeds while posing no damage to the environment. Intercropping, particularly cereal + legume combinations, can boost output and productivity by better using resources, reducing risks and bringing stability to rainfed areas (Mishra and Elamathi, 2009). Even if some weeds sprout despite the intercropping, the amount and frequency of herbicides required will be far lower than those advised in pure stand crops. As a result, intercropping may either eliminate or significantly reduce the usage of herbicides. Weed management research in India has mostly focused on monocropping, with little information on weed control in intercropping systems. As a result, there is an urgent need for weed control research in intercropping systems with pulses as a component crop to fulfil the need for cereals and pulses to supply diet for the nation's food and nutritional security. Keeping these things in the view present experiment was undertaken.

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MATERIALS AND METHODS

Study location

The field experiment was conducted at Zonal Agricultural Research Station, University of Agricultural Sciences,

Bengaluru, situated in the eastern dry zone of Karnataka under irrigated ecosystem. The rainfall data of the experimental site was given in Fig 1.

Experimental design and field management

Experiment was laid out in RCBD with factorial concept and replicated thrice. There were 15 treatment combinations involving three intercrops (I_1: Cowpea, I_2: Field bean, I_3: Pole bean) and five weed management practices (W_1: Pendimethalin @ 1.5 kg a.i./ha as pre-emergence spray; W_2: Alachlor @ 1.5 kg a.i./ha as pre-emergence spray; W_3: Two hand weedings at 15 + 30 DAS; W_4: Oxyflurofen @ 0.1 kg a.i./ha as pre-emergence spray; W_5: Unweeded check).

Soil characteristics

The soil was red sandy loam in texture at the experimental site. The soil pH was 5.98 and EC was 0.35 dS m^{-1}. The organic carbon content was 0.48% and the N, P_2O_5 and K_2O available were moderate (325.60, 29.23 and 281.87 kg/ha, respectively).

Spacing, manure and fertilizers

Specification	Maize	Cowpea	Field bean	Pole bean
Spacing	90/30 cm × 30 cm	30×10 cm	30×10 cm	30×10 cm
Variety	Hema (NAH-1137)	PKB-4	HA-3	Seminis
N, P_2O_5, K_2O (kg/ha) RDF	150:75:40	10:30:24	10:20:10	63:100:75

The paired row configuration at spacing of 30/90 × 30 cm, the furrows were opened in between two pairs of maize rows and two rows of intercrops (Fig 2) were sown as per treatment details following recommended intra-row spacing as in the package of practices for respective crops under pure stand treatments.

Maize equivalent yield (kg/ha)

MEY (kg/ha) =

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

Nutrient uptake(kg/ha)

Nutrient uptake (kg/ha) =

$$\frac{\text{Nutrient concentration (\%)}}{100} \times \text{Total dry matter yield (kg/ha)}$$

Profitability

$$\text{Benefit: Cost ratio} = \frac{\text{Gross returns (Rs. /ha)}}{\text{Total cost of cultivation (Rs. /ha)}}$$

The market prices of the maize (Rs. 12.20 /kg), cowpea (Rs. 20 /kg), field bean (Rs. 20 /kg) and pole bean (Rs 25. /kg).

Statistical analysis

The experimental data collected were subjected to statistical analysis using Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984). The level of significance used in 'F' and 't' tests was P=0.05. Critical difference values were calculated, wherever 'F' test was found significant. Results have been interpreted and discussed based on the pooled data of two seasons.

RESULTS AND DISCUSSION

Growth attributes of maize

Significantly higher total dry matter accumulation was observed (Table 1) with maize + cowpea intercropping (175.35 g) as compared to maize + pole bean intercropping (158.9 g) at 90 DAS. The higher total dry matter accumulation under maize + cowpea intercropping system was mainly attributed to significantly higher plant height (178.75 cm), number of leaves (10.41), leaf area (5282 cm^2/plant), LAI (2.93) as compared to maize + pole bean intercropping system, plant height (162.18), number of leaves (9.50), leaf area (4805 cm^2/plant, respectively), LAI (2.67). The higher growth parameters under maize + cowpea intercropping system were mainly attributed to lower weed population and higher weed control efficiency. These results are in conformity with the findings of Pandey *et al*. (2003); Jayaraj (1991).

Among the different herbicide treatments, significantly higher total dry matter production at 90 DAS (204.41 g/plant) was recorded in pre-emergence application of pendimethalin 30% EC @ 1.50 kg a.i./ha followed by pre-emergence application of alachlor 50% EC @ 1.50 kg a.i./ha (197.89 g/plant) which were at par with each other. Significantly lower dry matter production 90 DAS (68.44 g/plant) was recorded weedy check.

The higher total dry matter accumulation under pre-emergence application of pendimethalin 30% EC @ 1.50 kg a.i./ha was mainly attributed to significantly higher plant height (197.91 cm), number of leaves (11.84), leaf area (6148 cm^2/plant), LAI (3.42) as compared weedy check, plant height (107.78 cm), number of leaves (5.19), leaf area (2059 cm^2/plant), LAI (1.15). The higher growth parameters under pre-emergence application of pendimethalin 30% EC @ 1.50 kg a.i./ha was mainly attributed to significantly lower total weed, total weed dry weight and higher weed control efficiency. Similar observations were made by Shekhawat *et al.* (2002) and Mishra and Elamathi (2009).

Yield and yield attributes of maize

Significantly higher grain yield (5842 kg/ha), stover yield (7035 kg/ha) was recorded in maize + cowpea intercropping system (Table 2). The higher yield might be due to the complementary effect of cowpea which favoured the source-sink relation in maize and produced better yield components which resulted in higher maize grain yield (Chalka and Nepalia, 2006). In addition to this, the higher canopy coverage by cowpea has resulted in reduction in total weed

population, total weed dry weight and higher weed control efficiency, Similar observations were made by Shekhawat *et al.* (2002) and Mishra and Elamathi (2009).

Likewise, grain yield of maize (Table 2) was significantly influenced by various weed control treatments. The higher grain yield was recorded with two hand weedings at 15 and 30 DAS (7096 kg/ha) than other treatments. Weedy check recorded significantly lower grain yield (2286 kg/ha) compared to rest of the treatments. The improvement in yield by the former treatment over later treatment was to the tune of 210.41%. Among the weed control treatments, pendimethalin 30% EC @ 1.50 kg a.i./ha has recorded significantly higher grain and stover yield (6589 and 8033 kg/ha, respectively) followed by alachlor 50% EC @ 1.50 kg a.i./ha (6393 and 7822 kg/ha, respectively) and oxyflurofen 23.5% EC @ 0.1 kg a.i./ha (5205 and 6353 kg/ha, respectively) as compared to weedy check (2286 and 2877 kg/ha, respectively). The increase in yield in these treatments was to the tune of 188.23, 179.65 and 127.69% over weedy check, respectively. The higher yield in the treatment (pendimethalin 30% EC @ 1.50 kg/ha) could be due to improved yield attributing parameters as compared to weedy check. This improvement in turn was due to improved growth attributes such as higher total dry matter production and distribution in different parts, higher leaf area and leaf area index. Thus the improvement in crop growth and yield components was the consequence of lower crop weed competition, which shifted the balance in favour of

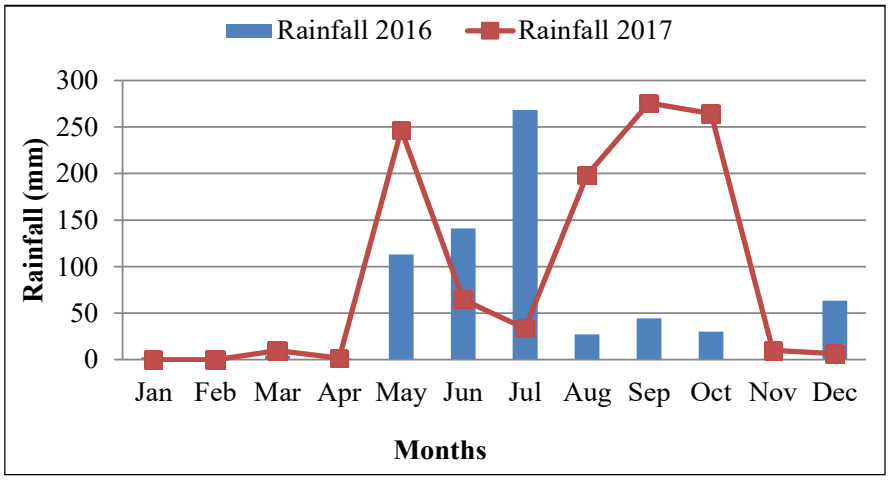


Fig 1: Rainfall data (2016 and 2017) of the experimental site.

Table 1: Growth parameters of maize as influenced by intercrops and weed management practices in maize based intercropping system.

Treatments	Plant height (cm)	No. of leaves	Leaf area (cm^2/plant)	Leaf area index	Dry weight (g/plant)
Intercrops (I)					
I_1: Cowpea	178.75	10.41	5282	2.93	175.35
I_2: Fieldbean	172.32	10.04	5083	2.83	169.82
I_3: Polebean	162.18	9.50	4805	2.67	158.90
S Em±	2.53	0.15	81.42	0.05	2.71
CD (p=0.05)	7.25	0.43	240.26	0.14	8.05
Weed management practices (W)					
W_1: Pendimethalin 30 % EC @ 1.5 kg ai/ha as PE spray	197.91	11.84	6148	3.42	204.41
W_2: Alachlor 50 % EC @ 1.5 kg ai/ha as PE spray	191.61	11.46	5952	3.31	197.89
W_3: Two hand weeding at 15 and 30 DAS	205.86	12.32	6395	3.56	212.04
W_4: Oxyflurofen 23.5 % @ 0.1 kg ai/ha as PE spray	152.25	9.11	4729	2.63	157.33
W_5: Unweeded check	107.78	5.19	2059	1.15	68.44
S Em±	3.32	0.19	102.49	0.06	3.40
CD (p=0.05)	9.51	0.55	305.53	0.18	9.98
Interaction (I×W)					
S Em±	5.81	0.37	189.10	0.11	5.99
CD (p=0.05)	NS	NS	NS	NS	NS

crop in the utilization of nutrients, moisture, light and space. Supporting results were recorded by Shekhawat *et al.*(2002); Meyyappan and Kathiresan (2005); Chalka and Nepalia (2006); Prasad *et al.* (2008); Mishra and Elamathi (2009).

Maize equivalent yield (MEY)

Among the intercropping systems, significantly higher maize equivalent yield was recorded (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 system, which was attributed to higher yield and market price of pole bean. The results are in conformity with the findings of Ashok (2011).

Two hand weedings at 15 and 30 DAS recorded (Table 2) significantly higher MEY (9428 kg/ha). It was mainly due to higher yield of both the crops due to weed free situation resulting from two hand weedings at 15 and 30 DAS. This enabled maximum utilization of nutrients, moisture, space and light by the crop which ultimately had favorable influence on growth and yield components. On the other hand, significantly lower maize equivalent yield was noticed in weedy check (3195 kg/ha). This was due to lower yield levels of both the crops in weedy check as a consequence of poor growth and yield components and minimum uptake of nutrients by the crop due to severe weed competition.

Among the weed control treatments pendimethalin 30% EC @ 1.50 kg/ha has recorded significantly higher MEY (8860 kg/ha) followed by alachlor 50% EC @ 1.50 kg/ha (8353) and oxyflurofen 23.5% EC @ 0.1 kg a.i./ha (6626 kg/ha). This can be attributed to higher yields of both the crops as a consequence of higher growth and yield components resulting from higher uptake of nutrients and better utilization of other resources due to lower weed population, weed dry weight and higher weed control

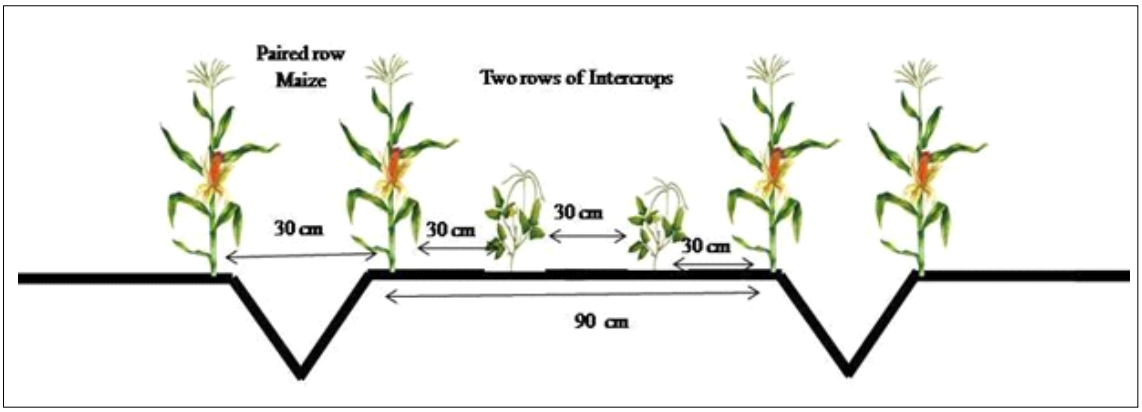


Fig 2: Planting arrangement of intercrop and main crop in paired row maize based intercropping system.

Table 2: Grain yield, stover yield and maize equivalent yield as influenced by intercrops and weed management practices in maize based intercropping system.

Treatments	Grain yield (kg/ha)	Stover yield (kg/ha)	MEY(kg/ha)
Intercrops (I)			
I_1: Cowpea	5842	7035	6915
I_2: Fieldbean	5514	6730	6738
I_3: Polebean	5186	6184	8224
S Em±	91.21	103.39	110.10
CD (p=0.05)	273.02	312.60	323.75
Weed management practices (W)			
W_1: Pendimethalin 30% EC @ 1.5 kg ai/ha as PE spray	6589	8033	8860
W_2: Alachlor 50% EC @ 1.5 kg ai/ha as PE spray	6393	7822	8353
W_3: Two hand weeding at 15 and 30 DAS	7096	8162	9428
W_4: Oxyflurofen 23.5% @ 0.1 kg ai/ha as PE spray	5205	6353	6626
W_5: Unweeded check	2286	2877	3195
S Em±	219.53	225.60	141.54
CD (p=0.05)	655.10	657.10	418.20
Interaction (I×W)			
S Em±	210.24	391.56	245.67
CD (p=0.05)	NS	NS	NS

efficiency with these treatments.Chalka and Nepalia (2006); Dwivedi and Shrivastava (2011); Ramesh and Nadanassababady (2005) observed the similar results.

Nutrient uptake by crops and weeds

The total nitrogen (99.53 kg/ha), phosphorous (27.37 kg/ha) and potassium (96.95 kg/ha) uptake by maize crop at harvest was significantly higher in maize + cowpea intercropping system (Table 3) as compared to maize + field bean (94.30, 25.96 and 91.85 kg/ha, respectively) and maize + pole bean (88.10, 24.21 and 85.82 kg/ha, respectively). This may be attributed to minimum crop-weed competition as a result of better control of weeds from initial stages resulting in better maize growth and development of maize crop leading to better nutrient uptake. Similar results were reported by Sinha *et al*. (2005), Pankaj and Angiras (2008), Ezung *et al*. (2018).

At harvest, the nitrogen, phosphorous and potassium uptake by weeds was significantly influenced by different intercrops (Table 3). Significantly lower nitrogen (14.68 kg/ha), phosphorus (4.76 kg/ha) and potassium (13.99 kg/ha) uptake was recorded in maize + cowpea intercropping as compared to maize + field bean (15.03, 4.86 and 14.41 kg/ha, respectively) and maize + pole bean (17.68, 5.70 & 16.95 kg/ha, respectively). The lower nutrient uptake by weeds in maize + cowpea system was a result of weed competition resulting in lower dry matter production, as also reported by Pankaj and Angiras (2008).

The nitrogen (112.81 kg/ha), phosphorous (31.05 kg/ha) and potassium (109.88 kg/ha) uptake by maize crop at harvest was significantly higher in treatments having pre-emergence application of pendimethalin 30% EC @ 1.50 kg a.i./ha. This treatment recorded 185.95, 185.12 and 185.99% increased uptake of nitrogen, phosphorous and

Table 3: Nutrient uptake (kg/ha) by maize and weeds as influenced by intercrops and weed management practices in maize based intercropping.

Treatments	Nutrient uptake by maize			Nutrient uptake by weeds		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Intercrops (I)						
I_1: Cowpea	99.53	27.37	96.95	14.68	4.76	13.99
I_2: Fieldbean	94.30	25.96	91.85	15.03	4.86	14.41
I_3: Polebean	88.10	24.21	85.82	17.68	5.70	16.95
S Em±	1.65	0.48	1.70	0.10	0.05	0.10
CD (p=0.05)	4.75	1.40	4.92	0.29	0.15	0.28
Weed management practices (W)						
W_1: Pendimethalin 30% EC @ 1.5 kg a.i./ha as PE spray	112.81	31.05	109.88	10.67	2.67	10.14
W_2: Alachlor 50% EC @ 1.5 kg a.i./ha as PE spray	109.27	30.09	106.43	11.83	2.96	11.24
W_3: Two hand weeding at 15 and 30 DAS	119.33	32.72	116.28	9.99	2.50	9.49
W_4: Oxyflurofen 23.5% @ 0.1 kg a.i./ha as PE spray	89.02	24.51	86.70	14.09	3.52	13.39
W_5: Unweeded check	39.45	10.89	38.42	32.40	13.88	31.33
S Em±	2.21	0.63	2.12	0.13	0.07	0.13
CD (p=0.05)	6.59	1.82	6.32	0.37	0.19	0.36
Interaction (I×W)						
S Em±	3.94	1.09	3.79	0.86	0.43	0.85
CD (p=0.05)	NS	NS	NS	NS	NS	NS

Table 4: Profitability of maize as influenced by intercrops and weed management practices in maize based intercropping system.

Treatments	Cost of cultivation (Rs. /ha)	Gross returns (Rs. /ha)	Net returns (Rs. /ha)	B:C ratio (Rs.)
Intercrops (I)				
I_1: Cowpea	38824	105467	66643	2.69
I_2: Fieldbean	38793	102391	63597	2.62
I_3: Polebean	40838	118881	78043	2.89
Weed management practices (W)				
W_1: Pendimethalin 30% EC @ 1.5 kg a.i./ha as PE spray	39384	132186	92803	3.35
W_2: Alachlor 50% EC @ 1.5 kg a.i./ha as PE spray	38374	125371	86996	3.26
W_3: Two hand weeding at 15 and 30 DAS	44258	139503	95245	3.15
W_4: Oxyflurofen 23.5% @ 0.1 kg a.i./ha as PE spray	38237	99899	61662	2.61
W_5: Unweeded check	37174	47606	10432	1.28

potassium, respectively as compared to unweeded control. This may be attributed to minimum crop-weed competition as a result of better control of weeds from initial stages resulting in better growth and development of maize crop leading to better nutrient uptake. Similar results were reported by Sinha *et al*. (2005) and Pankaj and Angiras (2008). But lower nitrogen, phosphorous and potassium uptake was recorded in unweeded control due to poor root growth and establishment as a consequence of severe crop-weed competition.

Profitability

Intercropping of maize with pole bean has recorded (Table 4) higher gross returns (Rs. 1,18,881 /ha), net returns (Rs. 78,043/ha) and B:C ratio (2.89) followed by maize + cowpea (Rs 1,05,467, 66,643 and 2.69, respectively) and maize + field bean (Rs. 1,02,391, 63,597 and 2.62, respectively). The higher B:C ratio in the above treatment was mainly due to the higher grain, stover yield and maize equivalent yield which in turn increased gross returns.

Among the weed management practices, Pre-emergent application of pendimethalin 30% EC @ 1.50 kg a.i./ha has recorded higher gross returns (Rs. 1,32,186 /ha), net returns (Rs. 92,803 /ha) and B:C ratio (3.35) followed by pre-emergence application of alachlor 50% EC @ 1.50 kg a.i./ha (Rs. 1,25,371, 86,996 and 3.26, respectively) and lower gross returns (Rs. 47,606 /ha), net returns (Rs. 10,432 /ha) and B:C ratio (1.28) were recorded in weedy check (Table 4). The higher gross returns, net returns and B:C ratio in the above treatment was mainly due to the higher weed control efficiency and lower weed index.

CONCLUSION

On two years of experimentation, the study can be concluded that intercropping of maize with legumes positively complimented the grain yield, stover yield, MEY and B:C ratio compared to other intercropping system. Among the weed management practices 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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Conflict of interest

The authors state that they have no recognized financial interests or personal relationships that could have influenced the work presented in this paper.

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