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Response of Legume intercropping systems and integrated weed management practices on physiological and yield traits of maize (*Zea mays* L.) in Northwestern agro-climatic zones of Tamil Nadu

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Abstract

Maize (*Zea mays* L.) is one of the most vibrant food grain crops under diverse edaphological conditions. However, the low productivity of maize in Tamil Nadu's northwestern agro-climatic zones where maize is the major crop can be attributed to a number of limiting factors, such as wider spacing and poor weed management practices. It's an essential to find a suitable integrated weed management practices and intercropping systems to enhance the productivity. The aim of the present study was to investigate the suitable legume based intercropping system and weed management practices for the maize in Northwestern Agro climatic zones of Tamil Nadu. The field experiment was conducted at Ramarkoodal village, Dharmapuri, Tamil Nadu during *kharif* 2020. This experiment was laid out in Split plot design with three replications. The main plots were assigned with three cropping systems, viz. maize, maize + blackgram, maize + cowpea and sub plots were five weed management practices viz., S_1 - Weedy check, S_2 - Stale seed bed + Rotary hoeing on 35 DAS, S_3 - Soil solarization + Rotary hoeing on 35 DAS, S_4 - PE Pendimethalin @ 0.75 kg a.i ha^{-1} + Rotary hoeing on 35 DAS and S_5 - Rotary hoeing at 20 DAS+ Hand weeding on 35 DAS. Application of pendimethalin at 0.75 kg/ha followed by one rotary hoeing on 35 DAS recorded the highest weed control efficiency and reduced weed populations and weed dry matter production at 60 DAS. The maize + cowpea system has positively influenced in plant height, LAI and dry matter production of maize at 30, 60 and 90 DAS respectively.

Maize (*Zea mays* L.) is an annual C4 plant native to Central America that belongs to the grassy family Poaceae. Among the maize growing countries India ranks 4th place in area and 7th place in production. It occupies around 4 percent of world maize area and 2 percent of total production. During 2018-19, the maize cultivated area in India reached 9.2

million ha[4]. In India, maize is cultivated in an area of 8.67 M ha with a production of 21.73 MT with a productivity of 2.54 t ha^{-1}. In Tamilnadu, it is cultivated in an area of 0.39 million hectares with production of 2.83 million tonnes and a productivity of 7.2 t ha^{-1} and also it occupies fourth position in Indian maize production (Tamilnadu Agriculture Department policy note, 2019-2020).

Maize's wider row spacing can be used to grow short-duration legumes, which is not only act as a smothering crop but also provides additional yield. Manual and mechanical weeding methods are difficult and expensive in intercropping systems due to shortages of labour and the labour cost is high. Chemical weed control enables in weed control in maize, but it is hard to find suitable broad spectrum herbicides because herbicides are often crop specific. Weed control approaches involving intercropping, herbicides and non-chemical methods are extremely crucial in maize and maize-based intercropping systems for providing effective and acceptable weed control and noticing high production[8]. Weed controlling practices like stale seedbed, soil solarization and rotary weeder were used in the experiment. However the stale seedbed technique was best suited for reducing the weed seed bank in the soil. Weeds are allowed to emerge for at least two weeks before being killed using this method. Then the soil solarization method is also called as soil-disinfestation. based on solar heating by mulching a soil with a transparent polyethylene during the hot season, thereby it helps for controlling weeds and soilborne pests The aim of this study was to identify the most profitable maize based intercropping system and weed management practices in Northwestern Agro climatic zones of Tamil Nadu.

The field experiment was conducted at Ramarkoodal village, Dharmapuri, Tamilnadu. during *kharif* season 2020. The experimental site is situated at 12°05' N latitude and 78° 00' E longitude at an altitude of 468 m above Mean Sea Level. This experiment was laid out in Split plot design with three replications. The main plots were assigned with three cropping systems, viz. maize, maize + blackgram, maize + cowpea and five weed management practices viz. S_1 - Weedy check, S_2 - Stale seed bed + Rotary hoeing on 35 DAS, S_3 - Soil solarization + Rotary hoeing on 35 DAS, S_4 - PE Pendimethalin @ 0.75 kg a.i ha^{-1} + Rotary hoeing on 35 DAS and S_5 - Rotary hoeing at 20 DAS+ Hand weeding on 35 DAS.

The experimental soil is clay loam and the fertility status was low in available nitrogen, medium in available Phosphorous and medium in available potassium. Maize (CO H6), Cowpea (CO 6) and Blackgram VBN (Bg) 4 seeds were used as the test variety of this experiment and these seeds were obtained from the Tamilnadu Agricultural University, Coimbatore, Tamilnadu, India. Maize intercropped with cowpea and blackgram as an additive series at (1: 1) was followed. The spacing of maize, cowpea and blackgram are 60 X 25cm, 30 X 15 cm and 30 X 15 cm respectively. The cowpea and blackgram seeds were sown in between the each pair of rows. Standard cultural practices and plant protection measures for the maize were followed as per the recommendations of the crop production guide of Agricultural crops in Tamilnadu (CPG, 2020).

Weed counts were performed at 15, 35, and 60 DAS. The weed count was recorded group-wise, namely grasses, sedges, and broad-leaved weeds. It was counted by using a 0.25 m^2 quadrat from four randomly chosen fixed locations in each plot and expressed in Number m^{-2}, as suggested by Burnside and Wicks 1965. Weeds found within the two 0.50 m^{-2} quadrats were removed, sun dried and oven dried for 72 hours at 70 °C. Weed dry weight was calculated and expressed in kg ha^{-1}. Weed control efficiency was calculated as per the procedure proposed by Mani *et al.,*[6] and expressed in percentage

WCE= WDC-WDT/WDC X 100

Where,

WDC - Weed dry weight in control plot (kg ha^{-1}), WDT - Weed dry weight in treatment plot (kg ha^{-1})

Weed interference and the effect of intercropping systems and weed management practices

In respect of weed management practices, Pre emergence application of pendimethalin 0.75 kg a.i. ha^{-1} with one rotary hoeing at 35 DAS (S_4) significantly recorded the lowest weed count. This was followed by S_2 (stale seed bed + rotary hoeing at 35 DAS). The weed count was higher under weedy check plot (S_1).The total weeds population was lower in (M_2S_4) Pendimethalin @ 0.75 kg/ha pre-emergence followed by one rotary hoeing in maize + cowpea, maize + blackgram

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

Treatments	15 DAS	35 DAS	60 Das
Intercropping systems			
M1	109.06 (10.4)	129.24 (11.3)	168.56 (13)
M2	63.2 (7.9)	69.94 (8.3)	100.26 (9.3)
M3	81.54 (9.05)	83.56 (9.1)	121 (11.02)
S.Ed	0.37	0.70	0.74
CD	0.82	1.7	1.6
Weed Management			
S1	131.33 (11.4)	160.7 (12..6)	193.83 (13.9)
S2	61.9 (7.8)	68.5(8.3)	101.23 (10.1)
S3	80.33 (8.9)	85.13 (9.2)	124.4 (11.1)
S4	56.86 (7.5)	57.3 (7.6)	88.66 (9.4)
S5	92.5 (9.6)	99.53 (10)	141.26 (11.9)
S.Ed	0.92	0.98	1.81
CD	1.89	2.01	3.7
MXS			
S.Ed	1.52	1.45	3.21
CD	3.32	3.6	6.84

Table-2. Weed DMP as influenced by intercropping system and weed management practices (kg ha^{-1})

Treatments	15 DAS	35 DAS	60 DAS
Intercropping systems			
M1	(222)14.92	(231.54) 15.23	(254.62) 15.97
M2	(155.63)12.5	(154.62) 12.45	aL(158.62) 12.61
M3	(178.85) 13.39	(181.66) 13.50	(193.5) 13.93
S.Ed	0.23	0.25	0.25
CD	0.6	0.68	0.69
Weed Management			
S1	(320) 17.90	(331) 18.21	(625) 25.01
S2	(73.88) 8.62	(69.5) 8.37	(104.98) 10.27
S3	(79.88) 8.97	(76) 8.75	(121.65) 11.05
S4	(50.21) 7.12	(56.28) 7.54	(89.65) 9.49
S5	(135.22) 11.65	(139.25) 11.82	(178.65) 13.38
S.Ed	0.17	0.51	0.39
CD	0.36	1.06	0.79
MXS			
S.Ed	0.34	0.85	0.62
CD	0.79	NS	NS

intercropping systems resulted in significantly lower weed population than sole maize (Table 1). The decline in weed density in intercropping systems may be attributed to the shading or smothering effect and competition stress created by more crops in a unit area having a suppressive effect on associated weeds, attempting to prevent the weeds from getting maximum growth[7].

About the weed control efficiency the stale seedbed method, soil solarization, rotary hoeing and hand weeding at 15 and 35 DAS was comparatively less than that of the pre-emergence herbicides application with one rotary hoeing. This might be due to initial stages the higher weed growth under irrigated condition up to the implementation of mechanical weeding at 15 and 35 DAS and subsequent emergence of grasses, sedges and broad leaved weeds.

At the same time weed competition in any crop can be varied mainly depends upon the accompanied weeds. Weeds and it relative ability of competence of weeds against crops. It can be accessed through nutrient removal by weeds. Nutrient depletion is a fraction of dry matter weight as a nutrient content in plants. Hence the weed management practices had a marked influence on nutrient removal by weeds at different stages of crop growth.

Among the main plot treatments, (M_2) (Maize + cowpea) reduced the removal of nutrients by weeds. This was due to decreased weed count and weed dry matter production

Table-3. Nutrient removal by weeds as influenced by intercropping system and weed management practices (kg ha^{-1})

Treatments	15 DAS	35 DAS	60 DAS
Intercropping systems	Nitrogen	Phosphorus	Potassium
M1	26.52	17.26	26.65
M2	12.01	10.64	14.41
M3	17.21	15.21	17.32
S.Ed	1.0	0.7	1.3
CD	2.1	1.5	2.7
Weed Management			
S1	28.66	19.65	28.47
S2	14.21	13.65	16.8
S3	16.14	15.01	20.14
S4	11.54	9.01	13.61
S5	20.59	16.84	23.84
S.Ed	1.1	0.7	1.4
CD	2.3	1.6	3.1
MXS			
S.Ed	-	-	-
CD	NS	NS	NS

Table-4. Effect of intercropping systems and weed management practices on grain yield kg ha^{-1}

Treatments	M_1 – Maize alone	M_2- Maize + Cowpea	M_3- Maize + Blackgram	**MEAN**
S_1- weedy check		M1	M2	M3
S_2- Stale seed bed + Rotary hoeing on 35 DAS	S1	4930	5316	5281
S_3- Soil solarization + Rotary hoeing on 35 DAS	S2	5759	6910	6537
S_4- PE Pendimethalin @ 3.3lit/ha + Rotary hoeing on 35 DAS	S3	5716	6530	6487
S_5- Rotary hoeing at 20 DAS+ Hand weeding on 35 DAS	S4	5771	7260	6888
MEAN	S5	5366	6137	6122
	M	**S**	**M at S**	**S at M**
S.Ed		NS		
CD (p=0.05)	166	236	201	319

Table-5. Effect of Intercropping systems and weed management practices on stover yield (kg ha^{-1})

Treatments	M_1 – Maize alone	M_2- Maize + Cowpea	M_3- Maize + Blackgram	**MEAN**
S_1- weedy check	7755	8264	8206	8075.00
S_2- Stale seed bed + Rotary hoeing on 35 DAS	8806	10410	9939	9718.33
S_3- Soil solarization + Rotary hoeing on 35 DAS	8769	9870	9807	9482.00
S_4- PE Pendimethalin @ 3.3lit/ha + Rotary hoeing on 35 DAS	8894	10869	10359	10040.67
S_5- Rotary hoeing at 20 DAS+ Hand weeding on 35 DAS	8318	9356	9345	9006.33
MEAN	8508.4	9753.8	9531.2	
	M	S	M at S	S at M
S.Ed				
CD (p=0.05)	221	321	343	401

for longer period of crop growth due to the smothering effect by the intercrops. Results obtained were in conformity with the findings of Katsaruware and Manyanhaire[5].

All the weed management treatments caused significant reduction in nutrient removal by weeds when compared to un weeded control during experiment I. In this experiment pre emergence application of pendimethalin 0.75 kg a.i. ha^{-1} followed by rotary hoeing at 35 DAS (S_4) registered lesser removal of weeds at different stages of cropping period. It was followed by (S_2) Stale seed bed and rotary hoeing on 35 DAS. This might be due to earlier controlling of weeds. The stale seed bed can be an effective method for lowering the density of annual weeds, as it has been demonstrated in many studies including weed control in maize production.

Growth and yield components of maize :

The yield components of maize viz., cob length, cob girth, number of grains per cob and test weight were higher under maize + cowpea intercropping system. This could be attributed to the complementary effect of cowpea, which favoured the source-sink relationship in maize and produced better yield components, resulting in higher maize grain yield, according to Chalka and Nepalia[2]. The application of pendimethalin @ 0.75 kg ha^{-1} as pre-emergence fb one rotary hoeing under maize + cowpea intercropping system resulted in increased grain yield. This might be due to better control of all categories of weeds. Besides that, lower nutrient depletion and lower DMP of weeds, which increased crop nutrient uptake, influenced crop growth and yield attributes that favoured grain yield.

According to the experimental results, the pre-emergence application of pendimethalin 0.75 kg a.i ha^{-1} followed by rotary hoeing on 35 DAS resulted in lower weed density, dry weight, higher weed control efficiency, and higher yield attributes and grain yield of maize under maize-based cowpea intercropping**.**

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