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Forage Intercropping and Fertilizer Levels on Productivity and Economics of Maize based Food Cum Fodder System

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A B S T R A C T

Field experiment was conducted to find out the influence of intercropping and fertilizer levels on the productivity and economics of maize based food cum fodder intercropping system at Tamil Nadu Agricultural University, Coimbatore during *kharif*2017.The experiment was laid out in split plot design and replicated thrice. The experiment consisted of four intercropping systems *viz.*, Sole grain maize, grain maize + fodder maize (1:1), grain maize + fodder maize + fodder cowpea (1:1) in alternate rows, grain maize + fodder maize + fodder moth bean (1:1) in alternate rows under main plot and three fertilizer levels, 100% RDF, 125% RDF and 150% RDF under sub-plot. The results of the experiment revealed that the grain yield of maize was higher under sole maize followed by maize + fodder maize + fodder cowpea and was comparable. Among the fertilizer levels, 150% RDF recorded higher yield followed by 125% RDF and both were comparable. Among the treatment combinations, higher land equivalent ratio and grain equivalent yield were recorded under the treatment combination of maize + fodder maize + fodder cowpea along with 150% RDF. However, the net return and BC ratio were higher under maize + fodder maize + fodder cowpea with 125 % RDF.

Introduction

Maize is one of the world's leading crops cultivated over an area of about 191.7 million hectares with a production of about 1123million tonnes and productivity of 5.86 tonnes of grain ha^{-1}. In India, maize is cultivated over an area of 9.28million hectare with a production of 27.72 million tonnes and the average productivity is 2.99 tonnes ha^{-1} (USDA, 2020). In India, at present maize is mainly grown for grain purpose. Maize has the potential to supply large amounts of energy-rich fodder for animal diets and its fodder can safely be fed at all stages of growth without any danger of oxalic acid, prussic acid as in case of sorghum (Dahmardeh *et al.*, 2009).

Thus, maize has become a major constituent of ruminant rations in recent years, where its inclusion in dairy cow diets improves fodder intake, increases animal performance and reduces production costs (Anil *et al.*, 2000).

Livestock rearing is an integral part in the Indian agriculture and plays a vital role in rural economy. India has about 15 per cent of world's livestock population with only two per cent of world's geographical area. Even with high animal population, the availability of the animal products to human beings in India is around 60 per cent of the requirement. The low productivity of livestock is a matter of concern, which is due to the poor fodder and feed reserves. The successful management of livestock will depend upon feeding of productive animals with enough quantity of nutritious fodders.

But small and marginal farmers are not able to allocate even a small portion of their land exclusively for fodder production in the cropping season. Hence, an integral approach of fodder production system aims at obtaining grain as well as fodder concurrently in space and time to cater the balanced nutrition of huge cattle population and also to increase the land productivity and ultimately increase the profit of the farm.

Maize provides high yield in terms of dry matter, but it produces fodder with low protein content. Because of low protein content, maize fodder alone is not enough to meet the nutrient demand of livestock (Lawes and Jones, 1971). The purchase of protein supplements is expensive and results in high feed costs. Hence, there is need of choosing the alternative strategies to increase the quality fodder production without affecting the grain production. Intercropping of fodder crops with grain is a good alternative to overcome the above problem.

The competition for nutrients is important and begins early in the growth of component crops in a cereal legume intercropping system. Competition between component crops is regulated by agronomic factors such as proportion of intercrops in mixture and fertilizer application. Among the essential nutrients, macro-nutrients such as, nitrogen, phosphorus and potassium play a crucial role in deciding the growth and yield. Intercropping legumes results in considerable removal of nutrients in the initial stage from the soil and thus to compensate the nutrient taken by intercrops, higher levels of NPK fertilizers must be applied (Ogutu *et al.*, 2012).

Growing non-food legumes in association with cereals particularly maize increase fodder production with less effect on maize grain yield. Integration of fodder legumes and fodder cereal into maize based cropping system through intercropping is one of the interventions for optimizing the productivity of a given land use, which can contribute towards alleviating livestock feed shortage in a mixed farming system. Fodder legume has a high protein concentration, palatability and digestibility and can be useful as a supplement to livestock feed with mature cereal crop residues that are often low in nutritive value (Hamdollah *et al., 2*009). In this backdrop, a study on food cum fodder system was planned to identify the agronomic practice which ensures maximum maize grain yield along with fodder. The study envisages the objectives to find out the influence of intercropping fodder maize and fodder legumes on the yield of grain maize and to find out the efficiency of intercropping system and economics.

Materials and Methods

Field experiment was conducted to find out the influence of intercropping and fertilizer levels on the productivity of maize based food cum fodder intercropping system at Tamil Nadu Agricultural University, Coimbatore during *kharif* 2017. The soil of the experimental field was sandy clay loam in texture.

The nutrient status of the soil during start of the experiment was low in available nitrogen (196 kg ha^{-1}), high in available phosphorus (28 kg ha^{-1}) and high in available potassium (748 kg ha^{-1}). The experiment was laid out in split plot design and replicated thrice. The experiment consisted of four intercropping systems *viz.,* Sole grain maize (I_1), grain maize + fodder maize (I_2) (1:1), grain maize + fodder maize + fodder cowpea (I_3) (1:1) in alternate rows, grain maize + fodder maize + fodder moth bean (I_4) (1:1) in alternate rows under main plot and three fertilizer levels, 100% RDF (F_1), 125% RDF (F_2) and 150% RDF (F_3) under sub-plot.

Maize hybrid COH (M) 6 with duration of 110 days was selected for this study. Fodder crops *viz.*, fodder maize variety African tall, fodder cowpea CO (FC) 8 and moth bean (TMV (MB)-1) were intercropped with grain maize. Maize seeds (COH (M) 6) were dibbled on one side of the ridges at the rate of one seed per hill adopting a spacing of 60 cm between rows and 25 cm within the row. For intercropping treatments, in I_2 (*i.e.*) grain maize + fodder maize, one row of fodder maize was sown in between the rows of maize on the other side of the ridges (1:1) as additive series.

In the case of I_3, grain maize + fodder maize / cowpea in alternate rows, between two rows of grain maize one row of fodder maize and fodder cowpea were sown in alternate rows. In the case of I_4, grain maize + fodder maize / moth bean in alternate rows, same method as in case of I_3 was followed. The diagrammatic illustration of the sowing methods for intercropping treatments is given in Fig. 1. For cowpea and moth bean, a spacing of 25 cm was followed in between plants. Adjacent to the treatment plots, sole fodder maize, sole cowpea and moth bean were also raised in dummy plots with same management practices to calculate the yield advantages. Yield was recorded in grain maize, fodder maize, fodder cowpea and fodder moth bean.The observations on garin yield of maize, green fodder yield of intercropped fodder maize, cowpea and moth bean were recorded. Land equivalent Ratio and Grain equivalent yield were calculated and economics worked out.

Land equivalent ratio (LER)

LER values for experiment were computed using the formula suggested by Willey (1979).

$$\text{LER} = \frac{\text{Iya}}{\text{PyA}} + \frac{\text{IyB}}{\text{PyB}}$$

IyA = intercrop yield of A IyB = intercrop yield of B

PyA= purecrop yield of A PyB = pure crop yield of B

Grain equivalent yield

Maize grain equivalent was arrived by equating the green fodder cost to that of the maize grain cost as suggested by Verma and Modgal(1983).

$$\text{Maize Equivalent} = \text{Yield of maize in intercropping system (kgha}^{-1}) + \frac{\text{Yield of intercrop kgha}^{-1} \times \text{Market price of intercrops (kg}^{-1})}{\text{Market price of maize (kg}^{-1})}$$

Results and Discussion

Grain yield

Among the intercropping systems, sole maize recorded the highest grain yield but was comparable with maize + fodder maize + cowpea intercropping (Table 1). This might be because intercropping fodder crops exerted competition with maize for growth resources, thereby affecting grain formation and development. Similar finding was reported by Getachew *et al., (*2013). Comparing the yield of maize grain obtained under different fertilizer levels, 150 % RDF recorded the highest grain yield and was comparable with 125 % RDF.

This increase in yield might probably be due to effective utilization of applied nutrients, increased sink capacity and nutrient uptake by crop. The yield potential of maize is mainly governed by the growth and yield components. The positive and significant improvement in yield attributes and nutrient uptake would have resulted in enhanced grain yield. The present findings are in line with the findings of Maddonni *et al.,* (2006). The positive responses of hybrid maize up to 300 kg N ha^{-1} as reported by Srikanth *et al.*, (2009) lend support to the present findings.

Stover yield

Regarding the intercropping systems, sole maize recorded higher stover yield (9,557 kg ha^{-1}) followed by grain maize + fodder maize + cowpea intercropping which was comparable with sole maize (Table 2) The least stover yield was recorded under maize + fodder maize + fodder mothbean intercropping.

This might be because intercropping fodder crops exerted competition with maize for growth resources, thereby affecting grain formation and development. Similar finding was reported by Getachew *et al., (*2013).

With respect to fertilizer levels, 150% RDF (9,026 kg ha^{-1}) registered significantly higher stover yield followed by 125% and both were comparable with each other. The least stover yield was recorded under 100% RDF. The positive and significant improvement in growth parameters and nutrient uptake would have resulted in enhanced stover yield. The positive responses of hybrid maize upto 300 kg N ha^{-1} as reported by Srikanth *et al.*, (2009) lend support to the present findings.

Fodder yield

Regarding the intercrops, green fodder yield of maize was higher under grain maize + fodder maize (Table 2). This is obvious as the population of fodder maize is double as that of the other treatments wherein one row of maize was replaced by either cowpea or moth bean.

The green fodder yield of maize linearly increased with increased fertilizer levels. This might be due to increased nutrient uptake associated with increased fertilizer application and better growth which resulted in enhanced accumulation of photosynthates. Similar results were reported by Rajput *et al.*, (1994) and Mahdi *et al.*, (2010).

Increase in fertilizer application increased the green fodder yield of cowpea and moth bean. The increase in green fodder yield by increasing the nitrogen application was due to increase in plant height, stem girth and no. of leaves per plant. Similar findings reported by Nadeem *et al.*, (2009) lend support to the present finding.

Evaluation of intercropping system

Land equivalent ratio

Land equivalent ratio reflects the advantage of intercropping over sole cropping system. The obvious reason for higher yield advantage in intercropping system is that the component crops differed in their use of natural resources and utilized them more efficiently resulting in higher yields per unit area than that produced by their sole crops.

Among the intercropping systems, comparatively higher LER was recorded under maize + fodder maize + fodder cowpea intercropping along with 150% RDF followed by maize + fodder maize + fodder cowpea with 125% RDF (Table 3). In the present study, LER values were greater than one in all intercropping systems which indicated yield advantage of intercropping. Productivity of the system increased and hence, yield increased and LER also increased. Similar findings reported by Dahmardeh *et al.*, (2010), Abraha (2013) and Reza *et al.*, (2013) lend support to the above results.

Grain equivalent yield

Grain equivalent yield is an important index in assessing the performance of different crops under a given circumstance. Based on the price structure, economic yield of component crops is converted into base crop yield *i.e.*, maize equivalent yield (Table 3). Higher grain equivalent yield of maize was obtained under maize + fodder maize + fodder cowpea intercropping along with 150% RDF is attributed to better performance and yields of both the component crops under intercropping system and due to higher return from intercrops. Similar findings were reported by Paudel *et al.*, (2015).

Economics

Among the treatment combinations, intercropping of grain maize with fodder maize + fodder cowpea along with 125% RDF recorded consistently higher net income and benefit cost ratio followed by maize + fodder maize + fodder cowpea with 150% RDF (Table 3).

This could be due to improvement in growth parameters and yield attributes as a result of increased fertilizer application which in turn resulted in higher yield, net income and benefit cost ratio. The yield reduction in base crop was compensated by intercrop yield and led to enhanced net income and benefit cost ratio. Similar results were reported by Sharma *et al.*, (2008) and Behere *et al.*, (2013).

Table.1 Effect of intercropping and fertilizer levels on grain yield of maize

Treatment	Grain Yield				
	I_1 - GM alone	**I_2 – GM + FM**	**I_3 - GM + FM + FCP**	**I_4 – GM + FM + FMB**	**Mean**
F_1 – 100% RDF	6580	3989	6457	4824	**5463**
F_2 – 125% RDF	7379	4039	7206	6578	**6301**
F_3 – 150% RDF	7499	4116	7354	6803	**6443**
Mean	7152	4048	7006	6068	
	I	**F**	**I x F**	**F x I**	
S.Ed	**181**	**158**	**315**	**316**	
CD (P=0.05)	**442**	**335**	**702**	**671**	

GM - Grain maize, FM - Fodder maize, FCP - Fodder cowpea, FMB – Fodder moth bean

Table.2 Effect of intercropping and fertilizer levels on stover yield of maize and green fodder yield of intercropped fodder maize, cowpea and moth bean

Treatment	Stover yield of maize (kg ha^{-1})	Green fodder yield (kg ha^{-1})		
		Fodder maize*	Fodder cowpea*	Fodder moth bean*
Intercropping systems (I)				
I_1– GM alone	9557	-	-	-
I_2 - GM + FM	7167	17219	-	-
I_3 - GM + FM + FCP	9509	10423	2433	-
I_{4-} GM + FM + FMB	8233	9687	-	1357
SEd	**322**	-	-	-
CD (P=0.05)	**789**	-	-	-
Fertilizer levels (F)				
F_1 – 100% RDF	7925	12765	1890	970
F_2 – 125% RDF	8899	13821	2520	1480
F_3 – 150% RDF	9026	14064	2890	1620
SEd	**237**	-	-	-
CD (P=0.05)	**503**	-	-	-
Interaction	**NS**	-	-	-

*Data not statistically analyzed

Table.3 Effect of intercropping and fertilizer levels on land equivalent ratio, maize equivalent yield and economics

Treatment	Land equivalent ratio	Grain equivalent yield (kg ha^{-1})	Gross return Rs.ha^{-1}	Net return Rs. ha^{-1}	B:C ratio
I_1F_1	1.00	6580	103061	56693	**2.22**
I_1F_2	1.00	7379	115641	66298	**2.34**
I_1F_3	1.00	7499	117503	66046	**2.28**
I_2F_1	1.12	5876	91884	40702	**1.80**
I_2F_2	1.12	6124	96122	42849	**1.80**
I_2F_3	1.13	6033	94837	38449	**1.68**
I_3F_1	1.36	7697	120036	68944	**2.35**
I_3F_2	1.42	8612	134154	81970	**2.57**
I_3F_3	1.45	8759	136460	80162	**2.42**
I_4F_1	1.14	5877	91473	40380	**1.79**
I_4F_2	1.39	7740	119912	67729	**2.30**
I_4F_3	**1.44**	**7960**	**123225**	**66927**	**2.19**

*Data not statistically analyzed

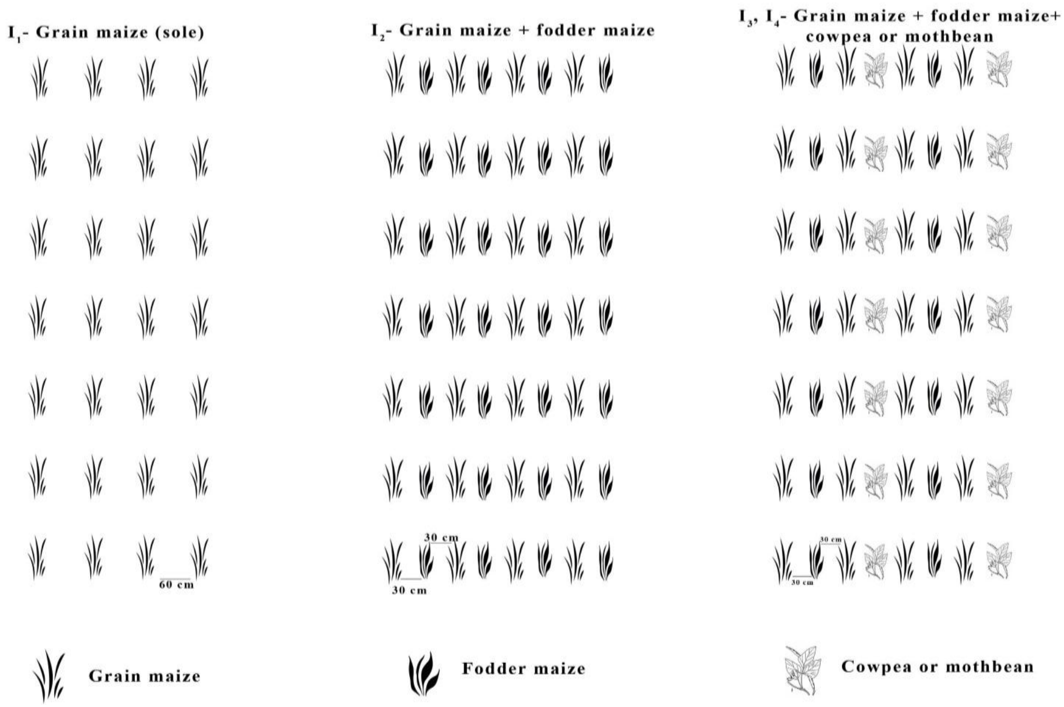

Fig.1 Row pattern of different intercropping systems

The results of the experiment revealed that grain yield of maize was higher under sole maize followed by maize + fodder maize + fodder cowpea and was comparable. Among the fertilizer levels, 150% RDF recorded higher yield followed by 125% RDF and both were comparable. Among the treatment combinations, maize + fodder maize + fodder cowpea intercropping recorded higher land equivalent ratio and maize grain equivalent yield along with 150% RDF. However, the net return and BC ratio were higher under maize + fodder maize + fodder cowpea with 125 % RDF.

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