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Effect of Inter and Sequential Cropping of Pulses in Little Millet (*Panicum sumatranse* L.) based Cropping System

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ABSTRACT

Background: Small millets and pulses are world's renowned crops for their nutritional significance. Being an underutilized species; rainfed farmers solely depend on them for their livelihood; which would be enhanced in a planned and efficient cropping system. The current study aimed to the identify suitable inter and sequential crops for rainfed little millet.

Methods: In this study, four cropping patterns with two different row proportions for intercropping [*viz*., (4:1), (6:1)] were used with little millet as a main crop. The cropping systems include - little millet + pigeonpea [(4:1), (6:1)] followed by a sequential horsegram; little millet + pigeonpea followed by moth bean and little millet + lablab [(4:1), (6:1)] followed by Horsegram and little millet + lablab followed by mothbean.

Result: Among them; a higher grain equivalent yield was observed in little millet + pigeonpea (6:1); followed by horsegram. However, higher dry matter, grain weight and higher individual crop yield was obtained in little millet + pigeonpea (6:1) followed by mothbean. Although individual mono cropping yields of these crops were higher; the pattern with little millet - pigeonpea (6:1) followed by horsegram could be recommended as a methodology to aid higher economic returns in shorter period.

Key words: Cropping system, Economics, Indices, Little millet, Net returns.

INTRODUCTION

Little millet (*Panicum sumatrense* L.) is one of the small millets which is an important food crop for the poor people in the tribal areas of India. This is suitable for shallow gravels and poor alfislos. Little millet is well known in Tamil Nadu and is grown extensively across the state especially in tribal areas. In most parts of Tamil Nadu, little millet is grown as a sole crop during *kharif* season which is followed by pulses like horsegram, blackgram and greengram or oilseeds like niger. Growing of single crop in a year or cereals as sole crop is not beneficial to fulfil the diverse demands of farmers as well as consumers. In monocropping, the land and other resources are underutilized and the land use efficiency could be increased by adopting suitable cropping pattern. Intercropping of legumes with cereals is a recognized practice for economizing the use of nitrogenous fertilizers and increasing the productivity and profitability per unit area.

Intercropping cereals with pulses is a very common combination and it provides more benefits in terms of efficient use of available resources like soil fertility improvement, less use of chemical fertilizers (Jensen *et al*., 2020), controlling erosion and run-off of water and enhancing diversity and higher total productivity of crops (Jan *et al*., 2016). The present experiment, therefore was planned to study the competitiveness of short duration little millet with long duration pigeonpea and lablab crops grown in intercropping systems with sequential crops of horsegram and moth bean in two different row ratios (4:1 and 6:1 ratios).

MATERIALS AND METHODS

A field experiment was conducted to investigate the relative performance and effects of legume intercropping system on productivity of little millet with two different row ratios under rainfed condition during the *kharif* seasons (2016-17), with a sequential cropping during *rabi* season at Centre of Excellence in Millets, Athiyandal, Tiruvannamalai District of Tamil Nadu using randomized block design with ten treatments of sole crops. The intercropping system treatments are., T_1- Little millet sole crop - Horsegram, T_2- Little millet sole crop - Mothbean, T_3- Little millet + Pigeonpea (4:1) -Horsegram, T_4- Little millet + Pigeonpea (4:1) - Mothbean, T_5- Little millet + Pigeonpea (6:1) - Horsegram, T_6- Little millet + Pigeonpea (6:1) - Mothbean, T_7- Little millet + Lablab (4:1) - Horsegram, T_8- Little millet + Lablab (4:1) - Mothbean, T_9- Little millet + Lablab (6:1) -

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Horsegram and T_{10}- Little millet + Lablab (6:1) - Mothbean. The treatments were replicated thrice and sown in replacement series. The little millet variety Co (Samai) 4, was sown with Pigeonpea [Co (Rg) 7], lablab (Co 13) followed by sequential crops of horsegram (Paiyur 2) and moth bean [TMV (Mb) 1]. Economic benefits like net returns and B:C ratio was calculated according to market price of each crop.

Indices for evaluation of cropping system

The cropping system approach is a holistic management of variant and invariant resources to optimize the food production. Various indices are used to assess and evaluate the efficiency and sustainability of the systems. These indices are generally computed from the data collected by traditional survey methods.

For comparison between treatments, the yields of all intercrops were converted into little millet equivalent yield on price basis. Grain equivalent yield (GEY) is used to convert the yield of different crops is to one unit.

LMGEY (kg/ha)=

$$\frac{\text{Yield of in intercrop (Yi)} \times \text{Price of intercrop (Pi)}}{\text{Price of basic crop (Pp)}}$$

Land equivalent ratio (LER) is the relative size of land under a sole crop system which will be necessary for obtaining the same yield as in intercropping system.

$$LER = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where,

Yaa and Ybb - Yield of 'a' and 'b' in sole crop situation.

Yab and Yba - Yield of 'a' and 'b' in intercropping situation.

Relative crowding coefficient (RCC) indicates whether a crop, when grown in mixed population, has produced more or less yield than expected in pure stand (RCC>1 = Intercropping system is advantageous).

$$RCC = \frac{Yab \times Zba}{(Yaa - Yab) \times Zab}$$

Where,

Zab- Sown proportion of 'a' in combination with 'b'.

Zba- Sown proportion of 'b' in combination with 'a'.

Aggressivity gives a simple measure of how much relative yield increase in component 'a' is greater than that for component 'b'.

$$\text{Aggressivity} = \frac{Yab}{Yaa \times Zab} \times \frac{Yba}{Ybb \times Zba}$$

The competitive ratio was calculated using the following formula.

$$CR = \frac{LERa}{LERb} \times \frac{Zba}{Zab}$$

Where,

LERa - Land equivalent ratio of 'a'.

LERb - Land equivalent ratio of 'b'.

Relative net return index (RNRI) is an important function to find the profitability in intercropping system and it is calculated by the formula given by Jain and Rao, (1980) (RNRI>1 = Intercropping system is advantageous)

$$RNRI = \frac{(Pi \times Yi) + (Pj \times Yj) \pm Dij}{Pi \times Yii}$$

Where,

Pi - Unit price of the product of the main crop (Rs/kg).

Pj - Unit price of the product of the inter crop (Rs/kg).

Yi - Yield of the main crop (kg/ha).

Yj - Yield of the inter crop (kg/ha).

Yii - Pure crop yield of 'i'.

Dij- Differential cost of cultivation of ij^{th} crop combination in comparison to i^{th} sole crop.

RESULTS AND DISCUSSION

Effect of intercrops on growth and yield attributes of little millet

Growth attributes like plant height and dry matter production was significantly influenced by intercropping. Plant height of little millet was found to be higher at all the stages under the treatments little millet + pigeonpea - horsegram at 6:1 ratio (T_5) followed by little millet + pigeonpea - mothbean at 6:1 ratio (T_6) (Table 1). Among the treatments higher dry matter in the treatment little millet + pigeonpea - horsegram at 6:1 ratio (T_5). Similar results were also obtained by (Kaushik and Sharma, 2017).

The yielding ability of a crop is reflected through its yield attributing characters. The yield attributes of little millet like number of productive tillers per hill and test weight is found to be increased when intercropped with pigeonpea at 6:1 ratio. Complementary relationship and mutualism among the intercrops also enhance the yield attributes of a main crop in an intercropping system. Several factors like; better utilisation of space, efficient utilisation of sunlight, nutrients and water; encompassing a higher nitrogen efficiency are reported to play a key role in the enhanced yield of little millet.

Effect of intercrops on yield of little millet

Grain yield is one of the essential factors for net returns and the grain yield of little millet was significantly influenced by various intercrops during harvest. Among all the intercropping patterns; higher grain and straw yields were recorded in little millet + pigeonpea-horsegram at 6:1 ratio (T_5) and it was on par with little millet + pigeonpea-mothbean at 6:1 ratio (T_6) (Table 1). This has been resulted due to an efficient use of nutrients, moisture, light and space as reported by Anchal Dass and Sudhishri, 2010.

Mutualism among intercrops has found to alleviate the yield in the cropping system pertaining to this; the use of medium duration pigeonpea as intercrops with little millet has resulted in a desirable fixation of N_2 in the soil. Hardarson and Atkins, (2003) found legume - cereal intercropping system increased the fixation of nitrogen by legumes.

Effect of intercropping on yield of inter and sequential crops

Intercrops and sequential crops had varied yields due to their distribution in the fields. Considering the intercrops; higher grain yield of pigeonpea and lablab was found higher in planting ratio of 6:1 compared to 4:1 ratio (Table 1).

Seed and haulm yield per hectare of pigeonpea, lablab, horsegram and mothbean were reduced in intercropping systems in comparison with their respective sole cropping systems. Such variation could be ascribed due to decrease in plant densities when grown as intercrops and higher competition among main crop and intercrops for natural resources like soil moisture, plant nutrient, space and sunlight responsible for higher photosynthesis rate resulting lower accumulation of dry matter per plant in comparison to dole crop. These results are similar to the findings of Choudhary (2009).

Effect of different intercropping treatments on little millet grain equivalent yield (LMGEY)

Apart from the competitive effects, prevailing price becomes an additional important factor for choosing the components of intercropping system and so intercrop yields were LER value as compared to sole crop, which indicated greater biological efficiency of the systems. Significantly higher value of LER was observed in the treatment (T_5) little millet + pigeonpea - horsegram (6:1) which established its superiority by recording a LER of 1.46. However, its land equivalent ratio was found on par with treatment (T_6) little millet + pigeonpea - mothbean (6:1) (LER = 1.44) (Table 2).

This was resulted due to higher yield of little millet in intercropping systems due to a better land utilization as compared to the sole crop. Beyond this; the complementary benefits from other components in the cropping system was also found to play a major role in higher LER (Choudhary, 2009).

Effect of different intercropping treatments on other cropping system indices (Table 2)

Among the intercropping treatments higher Relative crowding coefficient (RCC) value of 1.14 was obtained with little millet at 6:1 ratio followed by mothbean (T_6). Similar yield advantage with high, RCC was also observed in pigeonpea in an intercropping system with finger millet (Maitra *et al*., 2000)

The results showed that the aggressivity values of in little millet were negative and those of legume intercrops were positive, indicating little millet a dominated species and legumes the dominant species. This may be due to the reason that little millet is a short duration crop and is harvested at 75 DAS. At this stage the intercrops were at vegetative stage and this has created a competition free environment to the intercrops after the harvest of little millet. Similar trends for performance were also observed by Maitra *et al*., (2000).

The values of competition ratio computed indicate that among the intercropping systems, competitive ratio was

Table 1: Economics of little millet as influenced by intercropping (2016-17).

Treatments	Plant height (cm) (At harvest)	Dry matter production (kg/ha)	Little millet yield (kg/ha)		Yield of intercrops (kg/ha)	Little millet grain equivalent yield (LMGEY)	Yield of sequential crops (kg/ha)	Net income (Rs/ha)	B:C ratio
			Grain	Straw					
T_1- Little millet sole crop-Horsegram	108.0	5700	1340	4259	-	-	804	27,887	1.73
T_2- Little millet sole crop-Mothbean	110.3	5689	1365	4148	-	-	860	24,808	1.63
T_3- Little millet + Pigeonpea (4:1)-Horsegram	113.9	4714	924	3637	295	1463.5	612	29,168	1.83
T_4- Little millet + Pigeonpea (4:1)-Mothbean	111.6	4686	955	3574	308	1519.8	621	27,332	1.77
T_5- Little millet + Pigeonpea (6:1)-Horsegram	129.5	6543	1602	4774	231	2025.7	757	48,209	2.26
T_6- Little millet + Pigeonpea (6:1)-Mothbean	127.6	6352	1584	4656	224	1995.5	658	40,683	2.05
T_7- Little millet + Lablab (4:1)-Horsegram	107.8	4365	811	3233	1471	1154.3	561	9,610	1.22
T_8- Little millet + Lablab (4:1)-Mothbean	106.8	4165	803	3096	1395	1128.2	609	5,953	1.13
T_9- Little millet + Lablab (6:1)-Horsegram	119.4	5421	1163	4044	682	1321.8	549	16,090	1.37
T_{10}-Little millet + Lablab (6:1)-Mothbean	120.3	5162	1168	3852	693	1329.9	573	15,873	1.39
	5.80	281							
	12.11	588							

*Significant at P 0.05; NS- Non-significant at P>0.05.

Table 2: Effect of different intercropping treatments LER, RCC and RNRI.

Treatments	Land equivalent ratio (LER)	Relative crowding coefficient (RCC)	Relative net return index (RNRI)	Aggressivity		Competition ratio (CR)	
				Base crop	Inter crop	Base crop	Inter crop
T_3- Little millet + Pigeonpea (4:1)-Horsegram	1.02	0.54	1.00	-0.89	+0.89	0.48	2.06
T_4- Little millet + Pigeonpea (4:1)-Mothbean	1.07	0.60	1.04	-0.95	+0.95	0.48	2.06
T_5- Little millet + Pigeonpea (6:1)-Horsegram	1.46	1.07	1.49	-0.54	+0.54	0.69	1.38
T_6- Little millet + Pigeonpea (6:1)-Mothbean	1.44	1.14	1.47	-0.50	+0.50	0.72	1.38
T_7- Little millet + Lablab (4:1)-Horsegram	0.84	0.37	0.99	-0.44	+0.44	0.63	1.58
T_8- Little millet + Lablab (4:1)-Mothbean	0.82	0.37	0.96	-0.39	+0.39	0.65	1.53
T_9- Little millet + Lablab (6:1)-Horsegram	0.96	1.02	1.09	+0.23	-0.23	1.25	0.76
T_{10}-Little millet + Lablab (6:1)-Mothbean	0.98	1.06	1.03	+0.22	-0.22	1.23	0.78

Data's not statistically analysed.

higher when little millet is intercropped with pigeonpea at 4:1 ratio (2.06 and 2.06). The minimum CR value was observed in lablab intercropping at 6:1 ratio (0.76 and 0.78). The CR was highly influenced by the growth habit and initial establishment of the crops and this was parallelly observed by Jakhar *et al*., (2015) with finger millet and groundnut.

The relative net return index (RNRI) value of all treatments except little millet + lablab-horsegram at 4:1 ratio (0.99) and little millet + lablab-mothbean at 4:1 ratio (0.96) is found disadvantageous. All the other intercropping systems are advantageous. Hence other than these two treatments, the rest of the treatments were profitable and this is due to the spatial complementarity that was bound by substantial yield advantages from intercropping (Patra *et al*. 1999).

Economic analysis

Financial stability is the ultimate benefit of farming and considering this the highest gross return (Rs. 86,379/ha), net return (Rs. 48,209/ha) and benefit cost ratio (2.26) were recorded by little millet intercropped with pigeonpea (6:1) with horsegram as sequence crop during 2016 (Table 1). Little millet intercropped with pigeonpea (6:1) with mothbean as sequence crop was found to be the second best. Intercropping in farming systems alleviates the net produce of different crops and these diverse systems provide a higher cash return to small holding farmers than monocropping.

CONCLUSION

Thus, based on the results it may be concluded that to increase the productivity per unit area in little millet intercropping system under rainfed conditions of Tiruvannamalai district, growing of little millet and pigeonpea in 6:1 row ratio with horsegram or mothbean sequence have been found superior over the other intercropping systems and also growing sole crop of little millet alone.

Conflict of interest: None.

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