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Evaluation of different finger millet based intercropping systems in the north coastal zone of Andhra Pradesh

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Abstract
Field experiments were conducted at Agricultural Research Station, Vizianagaram during kharif 2015 and 2016 to evaluate the best finger millet based intercropping system under rainfed conditions. Twelve different intercrops along with farmer's practice of sole cropping were tested in Randomized Block Design with three replications. Experimental results revealed that all the growth and yield contributing characters of finger millet were significantly high in sole crop compared to different intercropping systems. However, finger millet equivalent yield was remarkably high in all intercropping systems compared to sole crop. Among different treatments, finger millet equivalent yield, gross income and net income were significantly high when finger millet was intercropped with Bhendi followed by Field bean, Cluster bean and Pigeon pea. The B:C ratio was significantly high for Finger millet+ Pigeon pea followed by Finger millet+Bhendi, Finger millet+Green gram and Finger millet+Black gram.

Keywords: Finger millet; Intercropping; Legumes; Equivalent yield; Bhendi; Pigeon pea.

Introduction
Ever increasing global population, shrinking of agricultural land holdings, food shortages in many parts of the world, as well as the threat of insufficient food supplies in the near future continues to stimulate more intensive agricultural exploration in a search for more productive alternatives. Intercropping is an ancient method of intensive agriculture that involves cultivation of two or more crops simultaneously on the same piece of land. Intercropping has been practiced in many parts of the world as a way to maximize land productivity in a natural and sustainable way. The idea behind the technique is that crops differ in their growth requirements and are complementary to each other and make a better overall use of available resources. Intercropping is more promising cropping system in dry land and rainfed farming situations where the occurrence of uncertain, ill-.distributed and limited annual rainfall is more common. Moreover, it is the most common practice used in sustainable agricultural systems which have an important role in increasing the productivity and stability of yield in order to improve resource utilization and environmental factors (Alizadeh *et al*., 2010) [1]. Today, intercropping is commonly used in many tropical parts of the world particularly by small-scale traditional farmers (Altieri, 1991) [2].

Millets are important staple food crops to the millions of the people in the arid and semiarid regions of the world due to their greater resistance to pests and diseases, good adaption to a wide range of environment and their good yielding capacity, and can withstand significant levels of salinity, short growing season, resistant to water logging, drought tolerant, requires little inputs during growth and with increasing world population and decreasing water supplies, represents important crops for future human use. Among millets, Finger millet known as ‘Ragi’ or 'chodi' is an important crop in India and is a dry land crop cultivated in both tropical and subtropical regions and is mainly cultivated in Andhra Pradesh, Karnataka, Tamilnadu and Kerala. Finger millet can be able to survive with 28% of paddy’s water needs – they are better adapted for current and future droughts. Rurinda *et al.*, (2014) [8] reported that finger millet provides food security to poor people. Growing of only millets is not much remunerative in the present scenario of agriculture to fulfill the diverse demand of consumers and rapidly growing population. Hence, it is an urgent need of inclusion of the legumes and vegetables in millet based cropping systems. Initial slow growth of finger millet will facilitate the better establishment of intercrops. Moreover growing of intercrops will suppress the unwanted weed growth and produces greater output from unit area than sole crop.

Midega *et al.,* (2010) [4] reported that intercropping of finger millet effectively suppress the disease of the crop. Finger millet also has wonderful health benefits as it increases bone strength, regulating blood sugar levels, protecting from risk of stroke by regulating cholesterol, helps in treating anaemia, increases lactation and also has anti aging properties.

Materials and methods

Field experiments were conducted at Agricultural Research Station, Vizianagaram during kharif seasons of 2015 and 2016 consecutively. The soil at the experimental site was sandy loam in texture, slight acidic in nature (pH-6.5), low in organic carbon content (0.35%) and soil available N,P and K are low (210kg/ha), high(88.25kg/ha) and medium (306.6kg/ha) respectively.

The experiment was laid out in Randomized Block Design with three replications. Experiment comprised of 13 treatments having different intercrop combinations with finger millet in 8:2 ratio. Intercrops include Green gram, Black gram, Cowpea, Cluster bean, Field bean, Pigeon pea, Ground nut, Cotton, Sorghum, Maize, Bhendi and Bajra. Finger millet variety VR-900 was used in this experiment with 30cmX10cm spacing. Green gram, Black gram, Cowpea and Ground nut crops were sown at 30cmX10cm spacing and remaining crops were maintained at the spacing of 60cm. In both years, crop was sown in the month of June. Nutrients were applied to all crops in the form of urea, single super phosphate and murate of potash as per their RDF. For finger millet 60-40-30kg NPK /ha was followed. Observations on yield attributes and yield were recorded to evaluate the effect of treatments. Taking into consideration of the prevailing market price of the intercrops, finger millet equivalent yields were calculated by converting the intercrop yields into finger millet yields. Moisture content in the field was estimated by oven drying method at 45DAS and 60 DAS at 15cm and 30cm depth in the root zone. Initial and final soil analyses were done to assess the effect of treatments on soil properties. Data was analyzed using standard statistical procedures.

Results and Discussions

All the growth and yield parameters of finger millet were significantly high in sole crop compared to intercropping (Table-1). Nigade *et al*. (2012) [5] and Ramamoorthy *et al.* (2004) [7] also reported similar results of low yield attributing characters of finger millet in intercropping. Plant height of finger millet intercropped with green gram and ground nut was on par with plant height in sole crop. Finger millet plant height was drastically reduced in remaining treatments due to the competition offered by intercrops. Productive tillers per hill and earhead length of finger millet were significantly high in sole crop. Among different intercroppings productive tillers of finger millet were high when intercropped with Green gram, Black gram and Cowpea; while earhead length was more when intercropped with Green gram, Black gram and Field bean. Number of fingers per ear was significantly high in sole crop and it was on par with intercropping with Field bean.

Finger millet grain yield was significantly high in the sole crop; however it was on par with grain yield obtained when intercropped with Black gram, Green gram and Cowpea (Table-1). Nigade *et al*. (2012) [5] also reported that intercropping of finger millet with blackgram or mothbean in 8:2 or 4:1 row proportion resulted in maximum grain and straw yield as well as net profit. Finger millet grain yield was drastically decreased when intercropped with Pigeon pea, Bajra, Sorghum, Maize and Cotton. Severe competition exerted by these crops on finger millet might lead to the reduction in grain yield. However, finger millet equivalent yield was significantly high when intercropped with Bhendi followed by Field bean, Cluster bean and Pigeon pea (Table-1). Maitra *et al.,* (2000) [3] reported that finger millet produced more yield under intercropping with pigeon pea compared to grown as sole cropping. Equivalent yield of finger millet was low when intercropped with Bajra, Sorghum and Ground nut.

Considering the economics of different intercroppings, gross income and net income was more from Finger millet+Bhendi system; however it was on par with Finger millet+Field bean, Finger millet+ Cluster bean and Finger millet+ Pigeon pea. The Benefit cost ratio was significantly high for Finger millet+ Pigeon pea followed by Finger millet+Bhendi, Finger millet+Green gram and Finger millet+Black gram (Table-2). Pradhan *et al.* (2014) [6] reported highest net returns and B:C ratio in finger millet + pigeon pea(4:1). Nigade *et al*. (2012) [5] and Ramamoorthy *et al*. (2004) [7] reported highest B:C ratio in Finger millet+Black gram(8:2) system. Low cost of cultivation and high grain price of Pigeon pea, Green gram and Black gram might be the reason for high benefit cost ratio.

Soil sample analysis after harvest of the crops revealed that pH, electric conductivity and organic carbon content were not significantly affected by different treatments (Table-2). Soil available phosphorus and Potassium were also not affected significantly by different treatments. But, soil available nitrogen was significantly high when intercropped with leguminous crops *viz.*, Pigeon pea, Green gram, Cluster bean, Field bean, Black gram and Ground nut (Table-3). Intercropping of pulses with finger millet can reduce the use of external inputs due to the complementary use of nutrient and water resources by the intercrop components. Legumes grown in low fertility soils could improve the soil health by fixing atmospheric N and may partially supplement the use of inorganic fertilizers. Legumes may also improve the production of cereal crops by adding much needed organic matter in the soils and by improving physical properties of soils. Lowest soil available nitrogen in Finger millet + Maize system might be due to the high nutrient requirement by Maize. In all the treatments having short duration shallow rooted intercrops *viz.,* Green gram, Black gram, Cow pea, Cluster bean, Ground nut and Bhendi; soil moisture content at 15cm depth was less compared to soil moisture at 30cm depth. High moisture requirement at flowering to pod formation stage of these crops might be the reason for low moisture content in the top layer. At 60DAS, soil moisture content at 30cm depth was found minimum in the treatments viz., finger millet+cotton, finger millet+pigeon pea and finger millet+field bean (Table-3).

Table 1: Growth and yield attributing characters of Finger millet as affected by different treatments (Pooled data of two years)

Treatments	Plant ht (cm)	Productive tillers/hill	Ear head length (cm)	No of fingers/ear	Finger millet grain yield(kg/ha)	FMEY (kg/ha)
T1: Sole crop of Finger millet/farmers practice	124	3.8	8.8	9.0	3189	-
T2: Finger millet + Green gram(8:2)	121	3.4	8.0	8.2	2988	3837
T3: Finger millet + Black gram(8:2)	117	3.1	7.9	8.3	3022	3836
T4: Finger millet + Cowpea(8:2)	114	3.1	7.1	8.1	2962	4439
T5: Finger millet + Cluster bean (8:2)	115	2.7	7.5	7.4	2826	4938
T6: Finger millet + Field bean (8:2)	115	2.4	7.8	8.4	2865	5318
T7: Finger millet + Pigeon pea (8:2)	107	2.5	7.0	7.2	2266	4521
T8: Finger millet + Ground nut (8:2)	118	2.7	7.5	8.1	2606	3340
T9: Finger millet + Cotton (8:2)	110	2.3	6.9	7.5	2332	3976
T10: Finger millet + Sorghum (8:2)	109	2.5	7.0	7.8	2313	2931
T11: Finger millet + Maize (8:2)	111	2.7	7.1	7.0	2320	3809
T12: Finger millet + Bhendi (8:2)	113	2.8	7.3	7.6	2694	6740
T13: Finger millet + Bajra (8:2)	109	2.6	6.7	7.3	2295	2772
S.Em±	2.2	0.10	0.13	0.23	85	-
CD (0.05)	6.5	0.30	0.39	0.67	248	-

Table 2: Effect of finger millet based intercropping systems on economics and soil properties (Pooled data of two years)

Treatments	Gross income (Rs./ha)	Net income (Rs./ha)	B:C	pH	EC (dS/m)	OC (%)
T1: Sole crop of Finger millet/farmers practice	66961	48867	2.70	6.3	0.19	0.34
T2: Finger millet + Green gram(8:2)	80569	61416	3.21	6.4	0.19	0.36
T3: Finger millet + Black gram(8:2)	80559	60876	3.09	6.2	0.16	0.34
T4: Finger millet + Cowpea(8:2)	93208	65719	2.39	6.2	0.20	0.34
T5: Finger millet + Cluster bean (8:2)	103697	74367	2.54	6.6	0.21	0.36
T6: Finger millet + Field bean (8:2)	111676	80751	2.61	6.4	0.21	0.35
T7: Finger millet + Pigeon pea (8:2)	94950	74406	3.62	6.5	0.21	0.33
T8: Finger millet + Ground nut (8:2)	70146	45043	1.79	6.4	0.21	0.35
T9: Finger millet + Cotton (8:2)	83488	58221	2.30	6.5	0.17	0.34
T10: Finger millet + Sorghum (8:2)	61551	40465	1.92	6.5	0.21	0.37
T11: Finger millet + Maize (8:2)	79981	56156	2.36	6.3	0.22	0.35
T12: Finger millet + Bhendi (8:2)	141536	110518	3.56	6.2	0.24	0.35
T13: Finger millet + Bajra (8:2)	58211	37639	1.83	6.4	0.17	0.33
S.Em±	-	-	-	0.12	0.019	0.013
CD (0.05)	-	-	-	NS	NS	NS

Table 3: Effect of finger millet based intercropping systems on soil available NPK and soil moisture content (Pooled data of two years)

Treatments	Available N_2(kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Soil moisture content at 45DAS		Soil moisture content at 60 DAS	
				15cm depth	30cm depth	15cm depth	30cm depth
T1: Sole crop of Finger millet/farmers practice	210	74.4	288	7.47	8.28	7.19	7.54
T2: Finger millet + Green gram(8:2)	246	74.6	273	6.77	8.74	9.78	9.42
T3: Finger millet + Black gram(8:2)	242	80.2	278	6.48	8.60	9.01	8.67
T4: Finger millet + Cowpea(8:2)	240	77.2	292	6.95	8.05	8.60	8.36
T5: Finger millet + Cluster bean (8:2)	245	81.2	282	6.91	7.65	7.52	7.82
T6: Finger millet + Field bean (8:2)	243	81.5	298	6.98	7.91	6.88	6.36
T7: Finger millet + Pigeon pea (8:2)	247	80.2	290	6.17	8.27	6.36	6.37
T8: Finger millet + Ground nut (8:2)	240	77.7	294	6.13	8.00	6.82	7.17
T9: Finger millet + Cotton (8:2)	208	78.1	312	6.72	6.42	6.51	5.84
T10: Finger millet + Sorghum (8:2)	213	77.7	290	8.01	7.08	6.17	6.45
T11: Finger millet + Maize (8:2)	199	78.9	305	6.10	7.57	5.92	6.55
T12: Finger millet + Bhendi (8:2)	214	77.8	309	6.65	7.24	6.47	7.06
T13: Finger millet + Bajra (8:2)	213	76.5	292	7.15	7.03	6.28	7.62
S.Em±	6.3	1.64	7.8	-	-	-	-
CD (0.05)	18.4	NS	NS	-	-	-	-

Conclusion

It can be concluded from the above experiment that intercropping of finger millet with Pigeon pea or Bhendi in 8:2 ratio is more profitable than sole cropping in North Coastal districts of Andhra Pradesh.

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