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Yield and economic advantage assessment in fingermillet based intercropping systems in *Alfisols* of Karnataka

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ABSTRACT : A field experiment was conducted at agronomy experimental unit, University of Agricultural Sciences, Bangalore during *Kharif* 2001 to evaluate fingermillet and castor intercropping. The experimental design followed was split plot repeated thrice. Intercropping systems were in main plots and fertility levels as sub plots. There were four intercropping systems fingermillet + pigeonpea (8:2), fingermillet + *Akkadi* (unproportion mixture of cowpea, sorghum, niger, avare) (5:1), fingermillet + castor (4:1) and 8:1 compared with sole fingermillet and castor. Sub plots nutrition levels included recommended fertilizers (50:40:25 kg NPK/ha), recommended fertilizers + poultry compost (5 tonne/ha) and 50 per cent recommended nitrogen through compost and rest of NPK through fertilizers. Biomass production, yield and economic advantage assessment indicated that intercropping systems were superior over sole crops. Pigeonpea or castor as intercrops after every eight rows of fingermillet found to be advantageous than traditional *Akkadi* intercrops (5:1). Combined application of fertilizers and 5 tonne/ha of compost resulted in higher yield and economic returns.

Key Words : Biomass, LER, Grain equivalent yield, *Akkadi*, Aggressivity, RCC

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Traditional mixed/ intercropping system is normally followed by many farmers to meet their domestic demands. Selection of crops and cropping systems in relation to soil and climate is a key factor for successful crop production. Fingermillet was predominant crop in *Alfisols* of Karnataka. Intercropping is a system of growing more than one crop species on the same piece of land at the same time. The benefits perceived or realized by intercropping systems include greater land use efficiency improvement in soil fertility. Intern, several factors like cultivar selection, seeding ratios, planting pattern and competition between mixture components affect the growth of species in intercropping (Caballero *et al.*, 1995, Carr *et al.*, 2004). Several legume species including pigeonpea, cowpea, soybean etc. were evaluated for their feasibility as an intercrop. The intercropping system of cereals + pigeonpea/legumes were tested and found to be profitable systems (Dhoble *et al*., 1990; Prasanna Kumar et al., 2008). Tall statured legumes were like pigeonpea are better option. But pigeonpea has the problem of more pest load, uncertain pod setting and lower yield potential look for other alternate crop. Castor was drought hardy crop well suited to dry land condition mainly due to many options of high yielding varieties and hybrids. A present trial was conducted with an objective to identify appropriate intercrop and row proportion with fingermillet under rainfed condition.

RESEARCH PROCEDURE

A field experiment was conducted during the crop season of 2001 at Agronomy field unit, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore on a sandy clay loam soil with a pH of 6.4. The experiment was laid out in split plot design in three replications with cropping systems in main plots and fertility levels in sub plots. Cropping systems comprised of sole fingermillet (C_1), sole castor (C_2), fingermillet + pigeonpea in 8:2 (C_3), fingermillet + castor in 4:1 (C_4) and fingermillet +castor in 8:1 (C_5). These systems were supplied with three fertility levels *viz.*, recommended dose of fertilizers (RDF) for both fingermillet and castor (F_1), RDF + 5t of poultry compost (F_2) and 50 per cent N through poultry compost and rest through fertilizers (F_3).

Fingermillet popular variety 'GPU-28' and castor cv. DCS-9 were sown in 0.3m spaced rows. In intercropping systems both the crops fertilizers were applied based on recommendation

of main crop of fingermillet. For sole crop of castor fertilizers were applied @ 38:38: 25 kg NPK/ha. Plots were laid out in E-W direction with a size of 19.5 m^2. Paired rows of pigeonpea and one row of castor (8:1) were planted after eight rows of fingermillet. For traditional *akkadi* system, seeds of sorghum, cowpea, lablab and niger were mixed in indefinite proportion and sown after five rows of fingermillet. Plant population of sole fingermillet and castor were maintained at 3,33,333 and 55,555 plants/ha, respectively. For intermittent biomass production observation plants were harvested from two rows of fingermillet on end of the plot. Fingermillet and castor were harvested at 118 and 183 days after planting, respectively. The total rainfall received during the crop season was 959 mm over normal rainfall of 929.9 mm. Poultry compost and fertilizers were as per treatment, nitrogen was applied at basal and 45 days old plants. Entire dose of P and K were applied at basal.

For data on total dry matter accumulation in fingermillet was recorded by hand harvest in one m row length at 30 days intervals. Inter crop castor and pigeonpea plants were harvested in one meter at 60, 120 and final harvest. At end of the season fingermillet was harvested in 12.5 m^2 area.

The reduction in fingermillet as influenced by intercropped castor was estimated by harvest of one meter row length of fingermillet in first and second rows adjacent to intercrop. The per cent reduction in grain yield due to intercropping was worked out over middle row of the plot (third row) from intercrop row.

Land equivalent ratio (LER):

LER used as criterion for measuring efficiency of intercropping advantage using the resources of environment compared with monocropping (Mead and Willey, 1980). It introduces the ground area (ha) needed in sole cropping to produce the equal yield of intercropping.

$$LER = p\frac{Yab}{Yaa} + \frac{Yba}{Ybb} \quad (1)$$

where,

Yab = Fingermillet yield when grown with castor

Yaa = Fingermillet grain yield in monoculture

Yba = Castor yield when intercrop with fingermillet

Ybb = Castor yield in monoculture

In LER=1 there is no difference between intercropping and monoculture. LER = 1 + x show that intercropping produce yield x per cent more than monoculture and finally LER < 1 indicates the dis-profitability of intercropping.

Aggressivity index (A):

Value indicates dominance degree of fingermillet in relation to castor could be investigated (McGilchrist, 1965).

$$Aab = \frac{Yab}{Eab} - \frac{Yba}{Eba} \quad (3)$$

where,

Aab = Fingermillet aggressivity in relation to castor

Yab = Actual yield of fingermillet intercropped with castor

Yba = Actual yield of castor intercropped with fingermillet

Eab = Expected yield of fingermillet intercropped with castor

Eba = Expected yield of castor intercropped with fingermillet

Relative crowding coefficient (RCC):

Competition intensity of fingermillet in relation to castor in an intercropped experiment with replacement arrangement (De Witt, 1960) could be calculated as follows :

$$Ka = \frac{Yab \times Zba}{(Yaa - Yab) \times Zab} \quad (4)$$

where,

Ka= Relative density coefficient of fingermillet

Yaa Yield of fingermillet in monoculture

Yab= Yield of fingermillet intercropped with castor

Zab= Mixing rate of fingermillet

Zba = Mixing rate of castor

If Ka = 1 interspecific and intraspecific competition have been equal. If relative crowding coefficient for each intercropped species (Ka and Kb) differed from 1, dominant crop is the one which has higher RCC and other one with lower RCC is dominated.

Monetary advantage (MA):

It is an estimate of economic advantage of an intercropping system higher the MAI value the more profitable is the cropping system (Ghosh, 2004).

$$MA = \text{Gross return} \times \frac{(LER-1)}{LER} \quad (6)$$

All variables were subjected to analyses of variance using a split-plot experimental design with intercropping as main plots and fertilization as subplots. Yield data were subjected to analysis of variance and means separated using the least significant difference at the probability of 0.05 level.

RESEARCH ANALYSIS AND REASONING

The data recorded during the course of investigation were tabulated, statistically analysed and results are intepreted here under appropriate heads:

Biomass production advantage:

Dry matter (DM) production and distribution in fingermillet was significantly decreased with irrespective of the intercrop over sole crop. The extent of reduction was maximum in fingermillet + *akkadi* system 15 per cent and lower with pigeonpea intercropping (5 %). Consistent decrease in fingermillet DM was observed throughout the season. Castor DM yield per plant was also decreased due to intercropping. It was more pronounced in fingermillet + castor (8:1) up to 27 per cent and over fingermillet + castor (4:1) (21%) and sole crop.

Total dry matter of fingermillet and castor was significantly differed due to intercropping. It was higher in intercropping systems compared to sole crops. The advantage can be noticed with the combined DM yield than individual performance. Significantly higher total dry matter was recorded in fingermillet + castor (4:1) over fingermillet + castor (8:1). Higher biomass contribution by castor may responsible for difference in two treatments. However, both the systems were superior over sole crop.

The dry matter production and its distribution to various plant parts was also influenced by the fertility treatments with the increase in duration of nutrient supply as in case of organic manures the dry matter production also increased. Combined application of fertilizers and 5 tonne/ha compost resulted in higher individual crop DM as well as combined DM yield.

Yield advantage:

The grain yield of fingermillet decreased under intercropping to 2494 to 2942 kg ha^{-1} as compared to sole fingermillet grain yield of 3354 kg ha^{-1}. However, fingermillet + castor (8:1) of fingermillet + redgram (8:2) among intercropping systems recorded significantly higher fingermillet grain yield (2942 and 2906 kg ha^{-1}). Application of recommended fertilizers and 5 t of compost ha^{-1} recorded significantly higher grain yield (3153 kgha^{-1}) as compared to recommended chemical fertilizer (2772 kg ha^{-1}). Reduction in grain yield due to intercropping and combined yield advantage was also reported by Shivakumar and Yadahalli (1996), Vivekananda (2001) and Reddy and Havanagi (1992).

Sole castor recorded higher seed yield (739 kg ha^{-1}) over

Table 1 : Yield of fingermillet and castor as influenced by interaction of cropping systems and fertility levels in fingermillet and castor intercropping

Treatments	Fingermillet grain yield (kg/ha)	Fingermillet straw yield (kg/ha)	Castor/pigeonpea seed yield (kg/ha)	Castor/pigeonpea stalk yield (kg/ha)
C_1F_1	3118	5745	-	-
C_1F_2	3798	7441	-	-
C_1F_3	3149	5571	-	-
C_2F_1	-	-	701	2945
C_2F_2	-	-	826	3240
C_2F_3	-	-	691	2863
C_3F_1	2856	4794	307	1786
C_3F_2	2981	4884	404	2039
C_3F_3	2881	3885	272	1800
C_4F_1	2696	4794	302	1445
C_4F_2	3029	6282	402	828
C_4F_3	2426	4546	326	1601
C_5F_1	2844	5359	167	1033
C_5F_2	3232	6334	243	1391
C_5F_3	2684	4880	204	1146

C_1: Sole fingermillet, C_2: Sole castor, C_3: Fingermillet + Pigeonpea (8:2), C_4: Fingermillet+Castor (4:1), C_5: Fingermillet+castor (8:1)

Table 2 : Economic returns and advantage evaluation indices of fingermillet+ castor intercropping system under rainfed condition at GKVK, Bangalore

	Grain yield (kg/ha)	FGEY (kg/ha)	Net returns (Rs./ha)	B:C ratio	MA (Rs./ha)	LER	AI	RCC	
								Ka	Kb
Sole fingermillet	3355	3354	19828	3.5	-	1.0			
Sole castor	739	1480	4146	1.8	-	1.0			
Fingermillet + Castor (4:1)	2717 (343)	3382	17640	3.2	3340	1.15	0.320	0.93	0.14
Fingermillet + Castor (8:1)	2920 (205)	3514	20147	3.6	4864	1.21	0.602	1.79	0.061

Figures in parenthesis are castor seed yield (kg/ha), MA- Monetary advantage, FGEY- fingermillet grain equivalent yield, LER- Land equivalent ratio, AI- Aggressivity index, RCC- Relative crowding coefficient, Fingermillet grain – Rs. 6000/tonne, Castor- Rs.12000/tonne

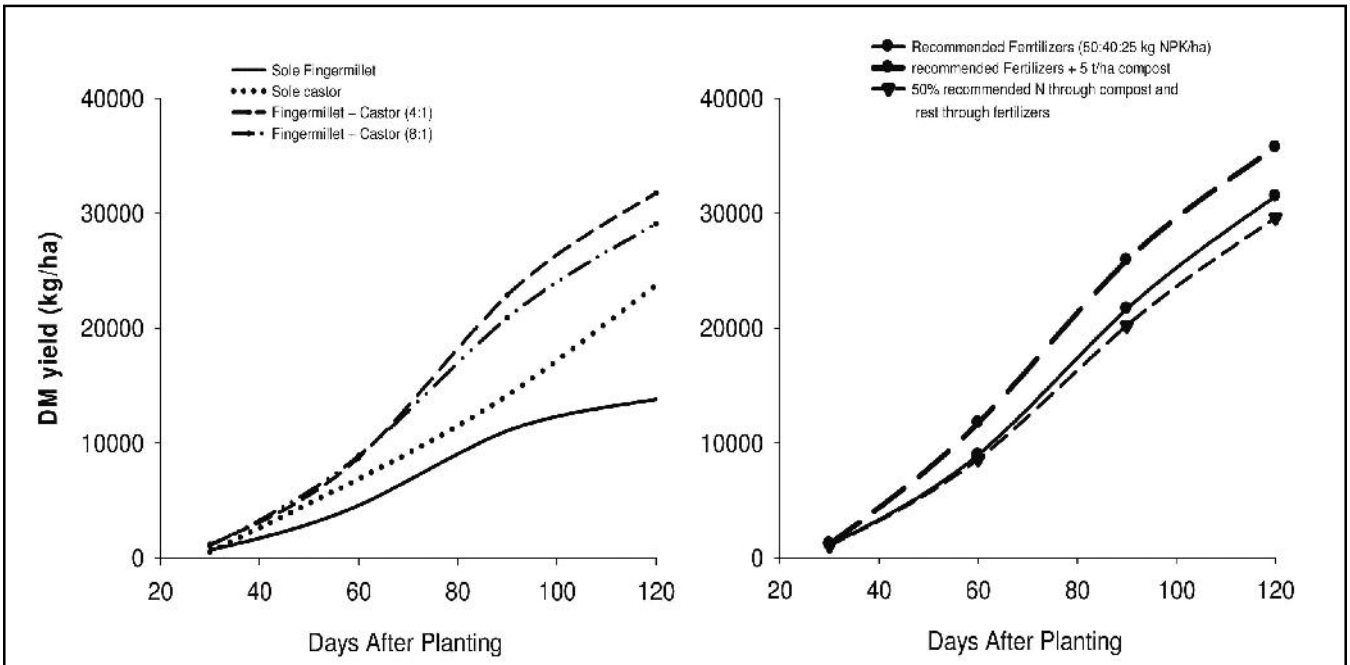

Fig. 1 : Combined fingermillet and castor dry matter yield in intercropping system and fertility levels at GKVK, Bangalore. Intercrop castor dry matter yield was calculated based on per plant and plants per hectare

intercropping systems. Higher population of castor in fingermillet + castor 4:1 row proportions recorded higher seed yield as compared to 8:1 system (Table 2). Patel *et al.* (1989) reported higher castor yield under sole cropping. Interaction effect irrespective of the intercropping systems application of recommended fertilizers and 5 t of compost ha^{-1} recorded significantly higher fingermillet grain, straw yield. Higher grain yield recorded with castor (8:1) row proportions and lower traditional *Akkadi* system (Table 2).

The competition effect of castor on fingermillet was evaluated based on the yield of the adjacent crop rows. It indicated that the fingermillet yield in first two adjacent rows was affected more than middle rows up to an extent of 5.44 to 13.22 per cent in intercropping systems (Table 3).

Performance and profitability of intercropping was assessed by different evaluation indices (Table 2). Fingermillet + redgram (8:2) recorded higher fingermillet grain equivalent yield (FGEY) compared to other systems. However, fingermillet + castor (8:1) recorded higher FGEY (3514 kg ha^{-1}) and lowest in sole castor intercropping. Higher price of redgram seeds (Rs. 15 per kg) was responsible for higher FGEY as compared to other treatments. The better utilization of resources was reflected in terms of the LER (Table 2). Both the intercropping systems involving castor at 4:1 (1.15) and 8:1 (1.21) has shown advantage compared to sole crops (1.0). Intercropping with castor has shown higher LER was reported by Yadav (1992)

Table 3 : Grain yield of fingermillet (g) in the adjacent rows of castor as influenced by different cropping system and fertility levels in fingermillet and castor intercropping

Treatments	Grain yield of fingermillet			Per cent reduction in grain yield of fingermillet over the second and third row	
	I Row	II Row	III Row	I Row	II Row
Cropping system					
Fingermillet + Castor (4:1)	85.3	89.9		13.2	0.0
Fingermillet + Castor (8:1)	100.3	104.9	110.9	9.6	5.4
Fertility levels					
100% recommended NPK (50:40:25 kg/ha)	94.9	100.2	108.1	12.2	7.3
100% NPK + 5 tonne of compost	107.5	111.6	116.8	8.0	4.5
50% N and 100% PK through fertilizers + 50%n through compost	90.8	97.4	104.5	13.2	6.9

and Padhi *et al.*, 2010).

Economic benefit :

Profitability of intercropping system was assessed with economic returns and resources use**.** Among the intercropping systems higher monetary advantage index values was recorded with fingermillet + castor (8:1) (Rs. 4864) as compared to fingermillet + castor (4:1) (Rs. 3340). Moreover, these advantages can also be assessed by the benefit obtained for each rupee invested. The benefit: cost ratio (B: C) and net returns was relatively higher with fingermillet + redgram and fingermillet + castor (8:1) intercropping (Table 2).

Competition functions:

Evaluation of intercropping in terms of interspecific competition, supplementary or complimentary interaction was assessed by different indices as presented in Table 2. Combined species aggressivity was more in fingermillet + castor (8:1) compared 4: 1 row ratio. However, in both the intercropping systems fingermillet was more aggressive than castor has indicated by RCC values (Table 2). Species yielding ability and performance depends on individual mutual competition and resource utilization (Tarhalkar and Rao, 1975).

Summary and Conclusion:

Results data indicated that fingermillet + castor (8:1) row proportion is a viable option as intercropping system may be alternative to fingermillet + redgram (8:2) intercropping. Combined application of recommended chemical fertilizers and compost @ 5t/ha would improve the productivity of fingermillet besides cropping systems and productivity. The greatest attributes were high dry matter production, minimum competition by castor as indicated by competition functions.

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