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EFFECT OF MODIFIED CROPPING SYSTEM ON CLIMATIC CHANGES IN SOUTHERN TRANSITIONAL ZONE OF KARNATAKA

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ABSTRACT
A field study on "Intercropping of blackgram (*Vigna mungo*) in finger millet (*Eleusinecoracana (L.)* Gaertn) under different methods of establishment" conducted at Agriculture College Hassan, University of Agricultural Sciences, Bangalore, Karnataka indicated that notably higher grain and straw yield of finger millet was recorded in sole finger millet followed by finger millet + blackgram in 4:1 row proportion, The intercropping of finger millet + blackgram (4:1) with transplanting method of establishment recorded higher crop equivalent yield and higher land equivalent ratio.

INTRODUCTION

India has a total geographical area of 328 million hectare, of which 56% of land is arable. About 60 per cent of the crops are grown as rainfed during monsoon. India has 3 million hectare area under mixed or mono-cropping system under rainfed upland conditions. Karnataka has 65 per cent of the total cultivated area under dryland farming (raitamitra. kar. nic. in). Agricultural productivity in these regions is low and with problems of instability and recurrent crop failures. For stabilizing and increasing the crop yields per unit area in these areas, it is required to adopt suitable cropping systems. This may include the introduction of new crops or improved management practices into existing production systems including intercropping. In recent years, new innovations in intercropping practices which are economically viable have been developed for few crop combinations. Further research involving the major crops of the area needs be taken up. Intercropping is a potentially beneficial system, shows substantial yield advantage over sole cropping and reduces risk (Singh and Singh, 1994). Intercropping practices would keep the optimum land resources and efficiently utilized during growth period of the crop (Mahapatra *et al.*, 1974 and Naiyar Ali *et al.,* 2015.). In addition to that an intercropping system can exploit the environment and physical resources more efficiently which may result into a more productive as well as economically viable system with minimum exploitation of land resources or even improving the soil fertility. With this context in the experiment at Agriculture College, Hassan, an effort was made to find out competitive and complementary effect of blackgram as an intercrop in finger millet and also to know the effect of different row proportions and methods of establishments. Inclusion of short duration legumes under finger millet intercropping has multifaceted advantage. Blackgram being a short duration legume suits for intercropping under direct sown and transplanted finger millet serving as insurance against climatic aberration and sustaining soil productivity. Beemaiah *et al.* (1988), Abbas *et al.* (1995), Muthuvel *et al.* (1984) and Singh (2000) also reported the significance of inclusion of blackgram in intercropping system. The possibility of maintenance of soil fertility by finger millet + blackgram intercropping system need to be studied. Hence, studies on inter-cropping in finger millet with blackgram was taken up with the objective of studying the effect of finger millet + blackgram intercropping systems on growth and yield of finger millet.

MATERIALS AND METHODS

The experiment was conducted at Agriculture college, Hassan situated in Southern Transitional zone of Karnataka at a latitude of 13º00[1] to 29º30[1] North, longitude of 76º06[1] to 13º06[1]East and an altitude of 943 meters above mean sea level with actual weather parameters for a season (January to December) indicated that normally total rainfall of the region is about 1000 to 1100 mm, with respect to temperature, maximum (37ºC) and minimum (17ºC) and relative humidity (80%). The soil of experimental site is sandy loam, neutral in soil reaction,

low in organic carbon, medium in available N and K and high in available P. The experiment was laid out in Factorial Randomized Complete Block Design (F-RCBD) treatments with three replications. The experiment was consisted of two factors with twelve treatment combinations in total, laid in factorial randomized complete block design with three replications.And the gross plot size of 5.8 x 3.6 m and net plot size of 5.4 x 3 m was used. For finger millet + blackgram intercropping system recommended dose of fertilizer is 50:40:25 kg NPK per hectare, for finger millet GPU-28 variety has been used with seed rate of 10-12 kg ha^{-1} for direct sown finger millet and 5 kg ha^{-1} for transplanted finger millet, for blackgram 20 kg ha^{-1} has been used. Sowing was done on 21st July and transplanting was done on 13th August. Blackgram was sown in two different times, during drill sowing and during transplanting blackgram is sown separately as an intercrop.

RESULTS

Yield parameters

Ear length (cm)

Ear length differed significantly due to intercropping of blackgram in finger millet as well as method of establishment. Significantly higher ear length was recorded with transplanted method of establishment (E_1:9.08 cm) as compared to direct sown method of establishment (E_2:8.72 cm). Among the row proportions higher ear length is recorded in sole crop (I_1:9.39) followed by 4:1 row proportion (I_6:9.05 cm).lowest Ear length was registered with 1:1 row proportion (I_3:8.45 cm). Method of establishment and their interactions with different row proportions found non-significant (Table 2).

Ear weight (g $plant^{-1}$)

Ear weight differed significantly due to intercropping of blackgram in finger millet as well as method of establishment. Significantly higher ear weight was recorded with transplanted method of establishment (E_1: 34.64 g $plant^{-1}$) as compared to directsown method of establishment (E_2: 33.13 g $plant^{-1}$). Among the row proportions higher ear weight is recorded in sole crop (I_1: 37.67 g $plant^{-1}$) followed by 4:1 row proportion (I_6: 34.79 g $plant^{-1}$) which was on par with 3:1 (I_5: 33.77 g $plant^{-1}$) and 2:1 (I_4: 32.22 g $plant^{-1}$) and found superior over rest of the treatments. Method of establishment and their interactions with different row proportions found non-significant (Table 2).

1000 grain weight (g)

Test weight differed significantly due to intercropping of blackgram in finger millet as well as method of establishment. Significantly higher test weight was recorded with transplanted method of establishment (E_1:3.42 g) as compared to direct sown method of establishment (E_2:3.32 g). Among the row proportions higher test weight is recorded in sole crop (I_1:3.84 g) followed by 4:1 row proportion (I_6:3.47 g) which was on par with 3:1 (I_5:3.28 g) and 2:1 (I_4:3.14 g) row proportions and

Table 1: Growth parameters of finger millet as influenced by finger millet + blackgram intercropping systems under different methods of establishment

Treatments	Plant height (cm)	Number of tillers ($plant^{-1}$)	Leaf area (cm^2 $plant^{-1}$)	Leaf area index	LAD	CGR	Total dry matter accumulation (g $plant^{-1}$)
Method of establishment							
E_1:Transplanting	94.1	6.9	1883	6.28	187.50	0.10	31.69
E_2:Direct sowing	91.9	4.8	1695	5.65	167.68	0.06	27.31
S.Em. ±	1.22	0.15	23.35	0.08	1.80	0.01	0.38
CD (p=0.05)	NS	0.44	69.37	0.23	5.35	NS	1.14
Row proportion							
I_1: Sole FM	99.3	6.8	1935	6.45	192.89	0.11	33.93
I_3: 1:1	89.6	5.0	1699	5.67	169.16	0.07	27.03
I_4: 2:1	90.5	5.5	1697	5.66	169.34	0.07	27.68
I_5: 3:1	91.4	5.8	1782	5.94	174.98	0.09	28.82
I_6: 4:1	94.2	6.3	1830	6.10	181.58	0.06	30.03
S.Em. ±	1.93	0.23	36.92	0.12	2.85	0.02	0.60
CD (p=0.05)	5.75	0.69	109.69	0.37	8.47	NS	1.80
Interaction							
E_1I_1	98.9	7.3	1949	6.50	194.01	0.13	34.60
E_{1-3}	91.3	6.3	1787	5.96	177.92	0.07	29.13
E_1I_4	91.8	6.6	1797	5.99	178.97	0.08	30.17
E_1I_5	94.0	7.0	1874	6.25	186.30	0.11	32.00
E_1I_6	94.6	7.3	2005	6.68	200.29	0.10	32.57
E_2I_1	99.8	6.3	1921	6.41	191.77	0.09	33.27
E_2I_3	87.9	3.6	1611	5.37	160.40	0.08	24.93
E_2I_4	89.2	4.3	1597	5.32	159.70	0.06	25.20
E_2I_5	88.8	4.6	1690	5.63	163.65	0.06	25.63
E_2I_6	93.9	5.3	1655	5.52	162.87	0.03	27.50
S.Em. ±	2.74	0.33	52.21	0.17	4.03	0.03	0.85
CD (p=0.05)	NS	NS	NS	NS	11.97	NS	NS

Methods of establishment; E_1: Transplanting; E_2: Direct sowing;
Row proportion (Finger millet + Blackgram); I_1: Sole finger millet; I_3: Finger millet + blackgram (1:1); I_4: Finger millet + blackgram (2:1); I_5: Finger millet + blackgram (3:1); I_6: Finger millet + blackgram (4:1)

Table 2: Yield and yield attributing parameters of finger millet as influenced by blackgram intercropping under different methods of establishment

Treatments	Ear length (cm)	Ear weight (g)	Test weight (g)	Number of productive tillers per plant	Grain yield (kgha^{-1})	Straw yield (kgha^{-1})	H.I	Protein (%) in grains
Method of establishment								
E_1:Transplanting	9.08	34.64	3.42	6.33	2303	8904	0.20	3.89
E_2:Direct sowing	8.72	33.13	3.32	5.07	2072	7561	0.22	4.40
S.Em. ±	0.12	0.46	0./04	0.12	58.19	125.88	0.01	0.07
CD (p = 0.05)	0.35	1.37	NS	0.35	172.88	374.02	NS	0.21
Row proportion								
I_1: Sole FM	9.39	37.67	3.84	6.50	3016	11410	0.21	2.66
I_3: 1:1	8.45	30.98	3.12	5.00	1403	5393	0.21	5.93
I_4: 2:1	8.75	32.22	3.14	5.17	1683	6035	0.22	4.41
I_5: 3:1	8.87	33.77	3.28	5.67	2168	8813	0.20	4.02
I_6: 4:1	9.05	34.79	3.47	6.17	2668	9511	0.22	3.71
S.Em. ±	0.18	0.73	0.07	0.19	92.00	199.04	0.01	0.11
CD (p = 0.05)	0.55	2.17	0.21	0.56	273.36	591.39	NS	0.34
Interaction								
E_1I_1	9.43	38.67	3.81	7.00	3146	12136	0.21	5.59
E_1I_3	8.83	31.97	3.15	5.67	1520	6306	0.19	4.10
E_1I_4	8.87	32.53	3.18	6.00	1720	6796	0.20	3.70
E_1I_5	9.00	34.63	3.44	6.33	2260	9020	0.20	3.46
E_1I_6	9.27	35.39	3.51	6.67	2870	10260	0.22	6.27
E_2I_1	9.34	36.67	3.87	6.00	2886	10683	0.21	4.73
E_2I_3	8.07	29.98	3.08	4.33	1286	4480	0.22	4.34
E_2I_4	8.63	31.90	3.10	4.33	1646	5273	0.24	3.96
E_2I_5	8.73	32.92	3.11	5.00	2076	8606	0.19	2.62
E_2I_6	8.83	34.19	3.43	5.67	2466	8763	0.22	2.69
S.Em. ±	0.26	1.03	0.10	0.27	130.11	281.48	0.01	0.16
CD (p = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Methods of establishment; E_1: Transplanting; E_2: Direct sowing

Row proportion (Finger millet + Blackgram); I_1: Sole finger millet; I_3: Finger millet + blackgram (1:1); I_4: Finger millet + blackgram (2:1); I_5: Finger millet + blackgram (3:1); I_6: Finger millet + blackgram (4:1)

found superior over rest of the treatments. Method of establishment and their interactions with different row proportions found no significant (Table 2).

Number of productive tillers per plant

Productive tillers differed significantly due to intercropping of blackgram in finger millet as well as method of establishment. Significantly higher number of productive tillers were recorded with transplanted method of establishment (E_1:6.33) as compared to with direct sown method of establishment (E_2:5.07). Among the row proportions higher number of productive tillers were recorded sole crop (I_1:6.5) followed by 4:1 row proportion (I_6:6.17) found superior over rest of the treatments. Method of establishment and their interactions with different row proportions found non-significant (Table 2).

Grain yield (kg ha^{-1})

Grain yield differed significantly due to intercropping of blackgram in finger millet as well as method of establishment. Significantly higher grain yield was recorded with transplanted method of establishment (E_1: 2303.33 kg ha^{-1}) as compared to direct sown method of establishment (E_2: 2072.67 kg ha^{-1}). Among the row proportions higher grain yield was recorded in sole crop (I_1: 3016.67 kg ha^{-1}) followed by 4:1 row proportion (I_6: 2668.33 kg ha^{-1}) and found superior over rest of the treatments. Method of establishment and their interactions with different row proportions found non-significant (Table 2).

Straw yield (kg ha^{-1})

Straw yield differed significantly due to intercropping of blackgram in finger millet as well as method of establishment. Significantly higher straw yield was recorded with transplanted method of establishment (E_1: 8904 kg ha^{-1}) as compared to direct sown method of establishment (E_2: 7561.33 kg ha^{-1}). Among the row proportions higher straw yield were recorded with sole crop (I_1: 11410 kg ha^{-1}) followed by 4:1 row proportion (I_6: 9511.67 kg ha^{-1}) and found superior over rest of the treatments. Method of establishment and their interactions with different row proportions found non-significant (Table 2).

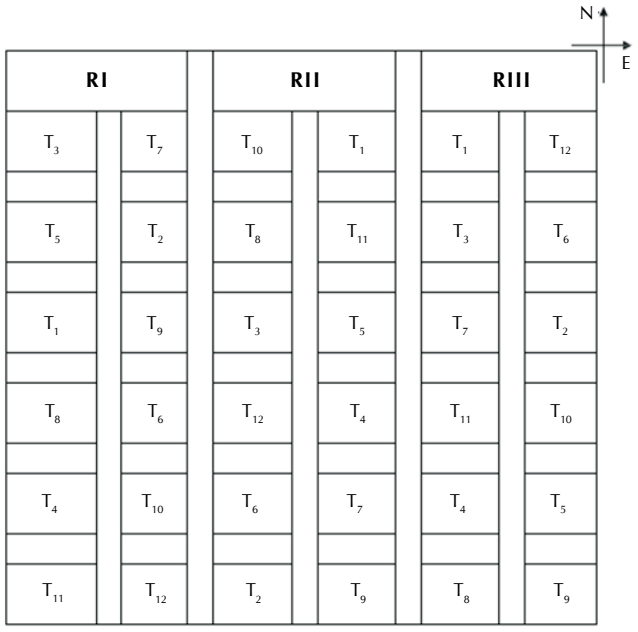
Harvest index

The impact of both main effects and interaction effects found non-significant. However, numerically higher harvest index was recorded with direct sowing method of establishment (E_2:0.22) and 4:1 row proportion (I_6:0.22).

Growth parameters

Plant height (cm)

Plant height did not differ significantly in any method of establishment. Significantly higher plant height was recorded with sole crop (I_1:103.02 cm) which was on par with 4:1 row proportion (I_6:96.37 cm). While lower plant height recorded with 1:1 row proportion (I_3:90.22 cm). Method of establishment



T_1 - Sole finger millet transplanted
T_2 - Sole blackgram (late sown)
T_3 - Transplanted Finger millet + Blackgram (1:1)
T_4 - Transplanted Finger millet + Blackgram (2:1)
T_5 - Transplanted Finger millet + Blackgram (3:1)
T_6 - Transplanted Finger millet + Blackgram (4:1)
T_7 - Sole finger millet (early sown)
T_8 - Direct sown Finger millet + Blackgram (1:1)
T_9 - Direct sown Finger millet + Blackgram (2:1)
T_{10} - Direct sown Finger millet + Blackgram (3:1)
T_1 - Direct sown Finger millet + Blackgram (4:1)

Figure 1: Plan of layout of the experiment

and their interactions with different row proportions found non-significant (Table 1).

Number of tillers per plant

Number of tillers per plant at harvest differed significantly due to intercropping of blackgram in finger millet as well as method of establishment. Significantly higher number of tillers were recorded with transplanted method of establishment (E_1:7.73) as compared to direct sown method of establishment (E_2:5.27). With respect to row proportions, higher number of tillers recorded in sole crop (I_1:7.67) which was on par with 4:1 row proportion (I_6: 6.83). Lowest number of tillers were recorded with 1:1 row proportion (I_3: 5.67). Method of establishment and their interactions with different row proportions found non-significant (Table 1).

Leaf area (cm^2 $plant^{-1}$)

At harvest, leaf area per plant differed significantly due to intercropping of blackgram in finger millet as well as method of establishment. Significantly higher leaf area recorded with transplanted method of establishment (E_1:1866.80 cm^2) as compared to direct sown method of establishment (E_2:1658.17 cm^2). Among the row proportions, higher leaf area was recorded in sole crop (I_1:1922.10 cm^2) followed by 4:1 row proportion (I_6:1800.98 cm^2). Lower plant height was recorded with 1:1 row proportion (I_3:1683.32 cm^2). With respect to the interactions E_1I_1 was given higher leaf area (2000 cm^2) which was on par with E_2I_1 (1930.30 cm^2) and significantly superior over rest of the treatments (Table 1).

Leaf area index (LAI)

leaf area index differed significantly at harvest due to intercropping of blackgram in finger millet as well as method of establishment. Significantly higher leaf area index was recorded with transplanted method of establishment (E_1:6.22) as compared to direct sown method of establishment (E_2:5.53). Among the row proportions significantly higher leaf area index was recorded in sole crop (I_1:6.41) followed by 4:1 row proportion (I_6:6.00). Lower plant height was recorded with 1:1 row proportion (I_3:5.61). With respect to interactions E_1I_6 was given higher leaf area index (6.67) which was on par with E_1I_1 (6.47) (Table 1).

Leaf area duration

Total dry matter production differed significantly due to intercropping of blackgram in finger millet as well as method of establishment. Significantly higher total dry matter production was recorded with transplanted method of establishment (E_1:31.69 g) as compared to direct sown method of establishment (E_2:27.31 g). Among the row proportions higher total dry matter production was recorded in sole crop (I_1:33.93 g) followed by 4:1 row proportion (I_6:30.03 g) and significantly superior over rest of the treatments (Table 1).

DISCUSSION

Yield parameters

The economic yieldof a crop is an outcome of a series of integrated interactions of various biological events involving biochemical and physio-morphological changes which takes place during its development in accordance with the supply of light, temperature, water and nutrients (Donald 1963).Thegrain and straw yield of finger millet variedsi gnificantly. Significantly higher grain and straw yield was recorded with transplanted method of establishment (E_1:2303 and 8904 kg ha^{-1}) as compared to direct sown method of establishment (E_2:2073 and 7561 kg ha^{-1}). The variation ingrain and straw yields between methods of establishments is attributed to the accumulation of photosynthates as reported by Reddy *et al*. (1992).

The transplanted finger millet and legume intercropping enhanced the availability of nutrients, higher dry matter accumulation in reproductive parts, more photosynthetic area up to harvest and higher uptake of nutrients.

Plant height and number of tillers are positively and strongly correlated with grain yield and straw yield, which resulted in increased yield in transplanted method of establishment was ascribed to the uniform crop stand and positive interaction between component crops.This was evidenced through findings of Reddy and Willey (1983); Anchaldass and Sudhishri (2008).This can be further substantiated through the superiority of yield attributes.

Lowergrain yield was recorded with direct sown method of establishment (E_2:2072.67 kg ha^{-1}), dueto improper intra row spacing maintained there is competition for all the essential resources. Consequently the grain yield was lower besides the poor growth and yield components. These findings arein

agreement with those of Reddy and Willey (1983). Incase of intercropping system, significantly higher grain yield was recorded in transplanted sole finger millet (I_1:3016 kg ha^{-1}) followed by 4:1 row proportion (I_6:2668 kg ha^{-1}). It may be due to the partial replacement and competition exerted by the component crop forthe growth resources during various stages of the crop growth. These results are in line with the findings of Ummed Singh *et al*. (2008).

Among the interaction effects transplanted solefinger millet (3146 kg ha^{-1}) recorded higher grain yield followed by direct sown sole finger millet (2886 kg ha^{-1}) and transplanted finger millet + blackgram in 4:1 row proportion (2870 kg ha^{-1}). It might be due to higher uptake of nutrients, higher dry matter accumulation in reproductive parts with the advantage of higher levels of nitrogen application in legume intercropping enhanced the availability of nutrients. Further, substantial role of legume component with respect to transfer of nutrients towards the finger millet crop also could be a reality. Similar findings were reported by Mishra *et al*. (2001).

Growth components

The variation in grain yield and yield parameters could be attributed to proportional variation in various growth parameters. Yield parameters were directly influenced by growth parameters under different methods of establishments and different row proportion in intercropping. The increase in ear length, number of productive tillers per plant, ear weight and test weight was due to superiority in growth parameters like plant height, leaf area and dry matter accumulation in various plant parts like leaves and stem.

The plant height of finger millet at different growth stages differed significantly due to different method of establishments. In sole cropping of finger millet, the growth components were higher than in intercropping system sand as the growth phase advanced, the height of plants increased gradually in all the treatments. Taller plants were observed in transplanted finger millet as compared to direct sown finger millet but the variation in plant height at 30 days was not statistically significant. The stage coincides with the germination and establishment of crop. During the germination, the nutrient demand of the crop is met with the reserved food in the endosperm of the seed. Further, the nutrient must undergo mineralization to become available besides proliferation of root system to absorb nutrients.

Leaf area and LAI are very important parameters that could relate to photosynthetic ability of plants. More number of leaves would results in higher leaf area and photosynthetic ability. A higher rate and amount of photosynthesis would in turn decide the dry matter production and its accumulation in different parts and finally affects the yield and yield attributing characters. Leaf area varied in different stages significantly except 30 days and continued the same trend at later stages.

The total dry matter accumulation in the leaves, stem and reproductive parts of finger millet differed significantly due to method of establishment and row proportion in intercropping system that increased progressively from 30 days to harvesting. At 30 days though it has not shown any significant difference between method of establishments, row proportions and their interactions. During the later stages of 60, 90 days and at harvest, among transplanting and direct sowing method of establishments, transplanted finger millet + blackgram in 4:1 ratio and sole finger millet among the intercropping row proportion proved better than direct sowing method of establishments and intercropping with 1:1, 2:1 and 3:1 ratio with respect to different growth attributes. The superiority of transplanting method of establishment in respect of growth components were also reported by Reddy *et al*. (1992) and Singh *et al*. (1998). While the results of row proportions are in conformity with the findings of Lingaraju *etal*. (2007); Mohankumar *et al*. (2012); Dutta and Bandopadhyay (2006); Thakur (2003).

Among the interaction of method of establishment and row proportion in intercropping, transplanting method of establishment with 4:1 row proportion and sole finger millet proved better for most of the growth attributes in finger millet. The lower response was observed in 1:1row proportion with direct sowing method of establishment indicatingthat finger millet being best suited crop for transplanting, the nutrient demand of intercropping system could be fulfilled with separate dosage of application for intercrops and crop demand.

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