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Effect of Finger Millet + Blackgram Intercropping System on Growth and Yield of Finger Millet

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Abstract

A field investigation on 'Intercropping of black gram (*Vigna mungo*) in finger millet (*Eleusine coracana* L.) under different methods of establishment' conducted during *kharif* season of 2012-13 at Agriculture College, Hassan, University of Agricultural Sciences, Bangalore, Karnataka recorded significantly higher grain and straw yield (3017 and 11410 kg ha-1, respectively) of sole finger millet. It was closely followed by finger millet + blackgram in 4:1 row proportion (2668 and 9511 kg ha-1, respectively). Intercropping of finger millet + black gram (4:1) with transplanting method of establishment recorded higher crop equivalent yield (3357 kg ha-1) and higher LER (1.11). Significantly higher uptake of nitrogen (73.9 kg ha-1), phosphorous (14.45 kg ha-1) and potash (32.29 kg ha-1) was noticed in finger millet + blackgram (4:1). Intercropping of finger millet + black gram (4:1) with transplanting method of establishment recorded higher gross returns (Rs.95,710 ha-1), net returns (Rs.48,796.50 ha-1) and B:C ratio (1.39).

Keywords: Intercropping, LER, CGR, Finger millet, Blackgram

Karnataka has 60 per cent of the total cultivated area under dry land farming. 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 need to be taken up. In this context an effort was made to find out the competitive and complementary effect of black gram as an intercrop in finger millet raised in different row proportions and methods of establishments. Inclusion of short duration legumes under finger millet intercropping has multifaceted advantage. Black gram 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. The possibility of maintenance of soil fertility by finger millet + black gram intercropping system also need to be studied. Hence, studies on intercropping in finger millet with black gram was taken up with the objectives to identify optimum row proportion for finger millet and black gram intercropping system, to study the different methods of establishment of finger millet for black gram intercropping and to assess the growth, yield, economics and intercropping advantage for finger millet and black gram intercropping system.

Material and Methods

The experiment was conducted during 2012-13 at Agriculture College, Hassan situated in Southern Transitional Zone (STZ) of Karnataka at a latitude of $13^0\ 00^1$ to $29^0\ 30^1$ North, longitude of $76^0\ 06^1$ to $13^0\ 06^1$ East and an altitude of 943 m above mean sea level. The normally total rainfall of the region is about 1000 to 1100 mm, with respect to temperature, maximum (37 °C) and minimum (17 °C) and relative humidity (80 %) was noticed. The soils of experimental site was sandy loam, neutral in soil reaction (pH 6.8), low in organic carbon (0.38%), medium in available N (310.5 kg ha^{-1}) and K (220 kg ha^{-1}) and high in available P (54.2 kg ha^{-1}). The experiment consisted of two

factors with twelve treatment combinations laid in factorial randomised complete block design with three replications. Sowing was done on 21st July, 2013 and transplanting was takenup on 13th August 2013. Black gram was sown in two different times, during drill sowing and during transplanting; black gram was sown separately as an intercrop.

Treatment details are as follows

E : Methods of establishment in finger millet:

E_1: Transplanting

E_2: Direct sown

I : Intercropping row proportions

I_1 : Sole finger millet

I_2 : Sole blackgram

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)

Treatment Combinations

$T_1 : E_1I_1$; $T_2 : E_1I_2$; $T_3 : E_1I_3$; $T_4 : E_1I_4$; $T_5 : E_1I_5$; $T_6 : E_1I_6$; $T_7 : E_2I_1$; $T_8 : E_2I_2$; $T_9 : E_2I_3$; $T_{10} : E_2I_4$; $T_{11} : E_2I_5$; $T_{12} : E_2I_6$

Plot Size

Experiment is laid with gross plot size of 5.8 x 3.6 m and net plot size of 5.4 m x 3m

Results and Discussion

I. Growth Components

Plant height of finger millet differed significantly with different row ratios. Sole finger millet recorded significantly taller plants compared to finger millet with black gram at different row ratio. Among row ratios, 4:1 recorded significantly greater plant height (94.2 cm) compared to the other row ratios (Table 1). However, method of establishment and its interaction with different row ratios did not influence plant height of finger millet. Number of tillers per plant differed significantly due to intercropping of black gram in finger millet and method of establishment. Significantly more number of tillers was recorded with transplanting (6.9) compared to direct sowing (4.8). With respect to row proportions, more number of tillers recorded in sole crop (6.8) was on par with 4:1 row proportion (6.3). Lowest number of tillers was recorded with 1:1 row proportion (5.67). Method of establishment and their interactions with different row proportions was found non significant. Similarly, leaf area per plant differed significantly due to intercropping of blackgram in finger millet and method of establishment. Significantly higher leaf area was recorded with transplanting (1883cm^2) compared to direct sowing (1695 cm^2). Among the row proportions, higher leaf area was recorded in sole crop (1935 cm^2) followed by 4:1 row proportion (1830 cm^2). Lower leaf area was recorded with 1:1 row proportion (1699 cm^2).

Interaction between method of establishment and row ratio did not differ significantly. Leaf area index differed significantly due to intercropping of blackgram in finger millet as well as method of establishment. Significantly higher leaf area index was recorded with transplanted crop (6.28) compared to direct sown one (5.65). Among the row proportions, significantly higher leaf area index was recorded in sole crop (6.45) followed by 4:1 row proportion (6.10). Lower leaf area was recorded with 1:1 row proportion (5.67). Interactions did not show any significant increase in leaf area index. Total dry matter production differed significantly due to intercropping of black gram in finger millet as well as method of establishment. Significantly higher total dry matter production was recorded with transplanting (31.69 g) as compared to direct sowing (27.31 g plant^{-1}). Among the row proportions higher total dry matter production was recorded in sole crop (33.93 g plant^{-1}) followed by 4:1 row proportion (30.03 G plant^{-1}) and significantly superior over rest of the treatments. Growth attributing characters like plant height, number of tillers and leaf area were more in transplanted finger millet. This was mainly attributed to the intensive care taken in the nursery for seedling establishment. Later crop sustained with better establishments of the roots and resulted in higher uptake of nutrients. Leaf area and LAI are very

TABLE 1

Growth parameters of finger millet as influenced by finger millet + black gram inter cropping systems under different methods of establishment at harvest

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

important parameters related to photosynthetic ability of plants. More number of leaves would have resulted in higher leaf area and photosynthetic ability. A higher rate and amount of photosynthesis would have in turn increased the dry matter production and its accumulation in different parts of the plant. The superiority of transplanting method of establishment with respect to growth components were also reported. The results of effect of row proportions are in conformity with the findings of Lingaraju *et al.* (2007); Mohan Kumar *et al.* (2012) and Dutta *et al.* (2006).

II. Yield Parameters

The economic yield of 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). Grain and straw yield of finger millet varied significantly. Significantly higher grain and straw yields were recorded with transplanted crop (2303 and 8904 kg ha^{-1}, respectively) compared to direct sown method of establishment (2072 and 7561 kg ha^{-1}) (Table 2). The variation in grain and straw yields between the methods of establishments would be attributed to the accumulation of photosynthates. The transplanted finger millet and legume intercropping might have enhanced the availability of nutrients, resulted in higher dry matter accumulation in reproductive parts, delayed senescence 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, which was ascribed to the uniform crop stand and positive interaction between component crops. This was evidenced through findings of Anchal Dass and Sudhishri (2008). This can be further substantiated through the superiority of yield attributes.

Lower grain yield was recorded with direct sown method of establishment (2072 kg ha^{-1}). This was possibly due to non uniform intra row spacing which might have resulted in competition for all the essential resources. Consequently the grain yield was lower besides the poor growth and yield components.

In case of intercropping system, significantly higher grain yield was recorded in sole finger millet (3016 kg ha^{-1}) followed by 4:1 row proportion (2668 kg ha^{-1}). It may be due to the partial replacement and competition exerted by the component crop for the 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 sole finger millet recorded higher grain yield (3146 kg ha^{-1}) 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 and higher dry matter accumulation in reproductive parts, support higher levels of nitrogen in legume intercropping. Further, substantial role of legume component in transfer of nutrients towards the finger millet crop also could be a reality. Similar types of observations were also noticed in ear length, ear weight, test weight and number of productive tillers.

From the investigation it could be inferred that transplanting of finger millet is more advantageous with respect to growth and yield parameters than drilled sowing. Among the different row ratios, finger millet + blackgram (4:1) under replacement series was more economical than the other row combinations tested.

III. Total Uptake of Nutrients in Finger Millet

Total uptake of Nitrogen, Phosphorus and potassium in finger millet is reported in Table 3.

i) Nitrogen

Significant differences were observed in uptake of nitrogen with respect to row proportions. Significantly higher uptake of nitrogen was recorded in sole crop (I_1:26.97 kg ha^{-1}) which was on par with 4:1 row proportion (I_6:26.52 kg ha^{-1}). Lowest uptake of nitrogen was recorded with 1:1 row proportion (I_3:23.93 kg ha^{-1}). All the methods of establishment and their interactions with row proportions were found non-significant (Table 3).

ii) **Phosphorus**

Significant differences were observed in uptake of phosphorus with respect to row proportions. Significantly higher uptake of phosphorus was recorded in sole crop (I_1:8.76 kg ha^{-1}) which was on par with 4:1 row proportion (I_6:8.61 kg ha^{-1}). Lowest phosphorus uptake was recorded with 1:1 row proportion (I_3:7.50 kg ha^{-1}). None of the method of establishment and their interactions with row proportions were non significant.

TABLE 2

Yield and yield attributing parameters of finger millet as influenced by black gram intercropping under different methods of establishment at harvest

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

iii) Potassium (kg ha^{-1})

Significant differences were observed in uptake of potassium with respect to row proportions. Significantly higher uptake of potassium was recorded by sole crop (I_1:87.39 kg ha^{-1}) which was on par with 4:1 row proportion (I_6:83.66 kg ha^{-1}). Lowest potassium uptake was recorded in 1:1 row proportion (I_3:75.84 kg ha^{-1}). None of the method of establishment and their interactions with row proportions were found non significant (Table 3).

TABLE 3

Uptake of NPK (kg ha^{-1}) by finger millet as influenced by finger millet + blackgram intercropping system

Treatments	Nitrogen (kg ha^{-1})			Phosphorous (kg ha^{-1})			Potassium (kg ha^{-1})		
	Grain	Straw	Total Uptake	Grain	Straw	Total Uptake	Grain	Straw	Total Uptake
Method of establishment									
E_1:Transplanting	46.16	25.97	72.13	5.07	3.26	8.33	23.02	59.38	82.40
E_2:Direct sowing	44.51	25.04	69.55	4.91	3.16	8.07	22.39	57.75	80.14
S.Em.±	0.61	0.34	0.95	0.06	0.04	0.11	0.30	0.76	1.06
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Row proportion									
I_1: Sole FM	47.94	26.97	74.91	5.33	3.43	8.76	24.41	62.97	87.39
I_3: 1:1	42.54	23.93	66.47	4.57	2.94	7.50	21.19	54.65	75.84
I_4: 2:1	43.17	24.28	67.45	4.69	3.01	7.70	21.58	55.68	77.27
I_5: 3:1	45.89	25.81	71.70	5.13	3.30	8.43	22.96	59.23	82.20
I_6: 4:1	47.14	26.52	73.66	5.24	3.37	8.61	23.37	60.29	83.66
S.Em.±	0.96	0.54	1.50	0.10	0.07	0.17	0.47	1.21	1.68
CD (p=0.05)	2.86	1.61	4.46	0.30	0.20	0.50	1.39	3.59	4.98
Interaction									
E_1I_1	48.26	27.14	75.40	5.34	3.44	7.66	24.68	63.67	88.35
E_1I_3	43.38	24.40	67.78	4.66	3.00	7.93	21.53	55.54	77.07
E_1I_4	43.96	24.72	68.68	4.83	3.10	8.57	21.70	55.98	77.69
E_1I_5	47.28	26.59	73.87	5.22	3.35	8.71	23.24	59.96	83.21
E_1I_6	47.94	26.97	74.91	5.30	3.41	7.34	23.94	61.75	85.69
E_2I_1	47.63	26.79	74.42	5.32	3.42	7.47	24.14	62.28	86.42
E_2I_3	41.71	23.46	65.17	4.47	2.87	8.29	20.84	53.77	74.61
E_2I_4	42.38	23.84	66.22	4.55	2.92	8.51	21.47	55.38	76.84
E_2I_5	44.50	25.03	69.53	5.05	3.25	8.78	22.68	58.51	81.19
E_2I_6	46.34	26.07	72.41	5.18	3.33	8.73	22.80	58.82	81.62
S.Em.±	1.36	0.76	2.12	0.14	0.09	0.24	0.66	1.71	2.37
CD (p=0.05)	NS	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)

Uptake by Finger Millet

Nitrogen uptake by finger millet grain, straw and total nitrogen uptake was significantly higher in sole finger millet which was on par with finger millet + blackgram 4:1 and 3:1 row proportions (Table 3). The higher nutrient uptake in these row proportions could be attributed to enhanced nutrient availability to the plants resulting in higher dry matter production over 1:1 and 2:1 row proportions. Method of establishment and interactions have not shown any significant differences. Higher grain and straw yields were observed in sole finger millet and finger millet +

blackgram intercropping system. It is known fact that the finger millet is N responsive, producing higher biomass per unit of external application. The N uptake was very high in sole finger millet (74.91 kg ha^{-1}) which was on par with finger millet + blackgram 4:1 (73.66 kg ha^{-1}) and 3:1 (71.70 kg ha^{-1}) row proportions, as compared to 1:1 and 2:1 row proportions. It might be due to favorable influence of nitrogen on root proliferation and anchorage which in turn absorbs higher amounts of nutrients from Rhizosphere and supply to the crop resulting in higher dry matter production.

The enhanced values of yield attributing characters witnessed the tendency of nitrogen in accelerating growth, photosynthetic activity and translocation efficiency which might have contributed for higher nutrient uptake. The same is reported earlier by Omraj *et al*. (2007). Significantly higher phosphorous uptake was also observed in sole finger millet (8.76 kg ha^{-1}) which was on par with finger millet + blackgram 4:1 (8.61 kg ha^{-1}) and 3:1 (8.43 kg ha^{-1}) row proportions (Table 3). This was attributed further to the root proliferation. Significant improvement in K uptake by finger millet grain and straw was observed with the sole finger millet (8.76 kg ha^{-1}) which was on par with finger millet + blackgram 4:1 (8.61 kg ha^{-1}) and 3:1 (8.43 kg ha^{-1}) row proportions (Table 3). The increased K concentration in the soil with increased population of finger millet have resulted in increased uptake. Further, the nutrient losses might be lower in K (Table 3). Potassium has a key role in activation of enzymes, photosynthesis and protein synthesis. The continuous availability of K and higher efficiency resulted in more uptake of potassium as compared to other row proportions.

IV. Total Uptake of Nutrients in Blackgram

Total uptake of Nitrogen Phosphorus and Potassium in blackgram (kg ha^{-1}) is reported in Table 4.

i) Nitrogen (kg ha^{-1})

Significant differences were observed in uptake of nitrogen with respect to row proportions. Significantly higher uptake of nitrogen was recorded in sole crop (I_2:78.71 kg ha^{-1}). Lowest uptake of nitrogen was recorded with 3:1 row proportion (I_5:73.10 kg ha^{-1}) which was on par with 4:1 row proportion (I_6:73.98 kg ha^{-1}). None of the interactions with row were proportions found non significant (Table 4).

ii) Phosphorus (kg ha^{-1})

Significant differences were observed in uptake of phosphorus with respect to row proportions. Significantly higher uptake of phosphorus was recorded in sole crop (I_2:15.63 kg ha^{-1}). Lowest uptake of phosphorus was recorded with 3:1 row proportion (I_5:14.18 kg ha^{-1}) which was on par with 4:1 row proportion (I_6:14.45 kg ha^{-1}). None of the interactions with row proportions were found non significant (Table 4).

iii) Potassium (kg ha^{-1})

Significant differences were observed in uptake of potassium with respect to row proportions. Significantly higher uptake of potassium was recorded in sole crop (I_2:34.0 kg ha^{-1}). Lowest uptake of potassium was recorded with 3:1 row proportion (I_5:31.71 kg ha^{-1}) which was on par with 4:1 row proportion (I_6:32.29 kg ha^{-1}). None of the interactions with row proportions were found non significant (Table 4).

Uptake by Blackgram

Nitrogen uptake in blackgram was significantly higher in sole blackgram (Table 4). The higher nutrient uptake could be attributed to increased plant population of blackgram. The N uptake by blackgram was higher in sole blackgram (79.83 kg ha^{-1}) as compared to the row proportions (Table 4). It might be due to nitrogen fixation from atmosphere to nodules that creates favorable influence of nitrogen on root proliferation and anchorage which in turn absorbs higher amounts of nutrients from rhizosphere and supply to the crop resulting in higher dry matter production as also reported by Umesh (2008); Mohankumar *et al*. (2012). The enhanced values of yield attributing characters witnessed the tendency of nitrogen in accelerating growth, photosynthetic activity and translocation

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TABLE 4

Uptake of NPK (kg ha^{-1}) by blackgram as influenced by finger millet + blackgram intercropping system

Treatments	Nitrogen (kg ha^{-1})			Phosphorous (kg ha^{-1})			Potassium (kg ha^{-1})		
	Grain	Straw	Total Uptake	Grain	Straw	Total Uptake	Grain	Straw	Total Uptake
Method of establishment									
E_1:Transplanting	50.89	21.81	72.70	8.61	5.74	14.36	8.70	23.52	32.21
E_2:Direct sowing	49.97	21.42	71.39	8.46	5.64	14.11	8.45	22.85	31.30
S.Em.±	0.79	0.34	1.12	0.15	0.10	0.26	0.13	0.34	0.47
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Row proportion									
I_1: Sole FM	55.10	23.61	78.71	9.38	6.25	15.63	9.18	24.82	34.00
I_3: 1:1	51.78	22.19	73.98	8.67	5.78	14.45	8.72	23.57	32.29
I_4: 2:1	51.17	21.93	73.10	8.51	5.67	14.18	8.56	23.15	31.71
I_5: 3:1	47.13	20.20	67.33	8.22	5.48	13.70	8.44	22.83	31.27
I_6: 4:1	46.98	20.13	67.12	7.92	5.28	13.20	7.97	21.54	29.51
S.Em.±	1.24	0.53	1.78	0.24	0.16	0.40	0.20	0.54	0.74
CD (p=0.05)	3.70	1.58	5.28	0.72	0.48	1.20	0.60	1.61	2.20
Interaction									
E_1I_1	52.01	22.29	74.31	8.84	5.89	14.74	8.80	23.79	32.59
E_1I_3	51.60	22.11	73.71	8.58	5.72	14.30	8.75	23.65	32.40
E_1I_4	47.55	20.38	67.93	8.29	5.53	13.81	8.60	23.25	31.85
E_1I_5	47.40	20.32	67.72	7.97	5.31	13.28	8.01	21.65	29.66
E_1I_6	51.56	22.10	73.65	8.50	5.67	14.16	8.64	23.36	31.99
E_2I_1	50.75	21.75	72.49	8.43	5.62	14.05	8.38	22.65	31.02
E_2I_3	46.70	20.02	66.72	8.15	5.43	13.58	8.29	22.40	30.69
E_2I_4	46.56	19.95	66.51	7.88	5.25	13.13	7.93	21.43	29.36
E_2I_5	55.88	23.95	79.83	9.39	6.26	15.65	9.33	25.24	34.57
E_2I_6	54.31	23.28	77.59	9.37	6.25	15.61	9.02	24.40	33.42
S.Em.±	1.76	0.75	2.51	0.34	0.23	0.57	0.28	0.77	1.05
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Methods of establishment
E_1: Transplanting E_2: Direct sowing
Applicable only to the finger millet

Row proportion (Finger millet + Blackgram)
I_2: Sole blackgram 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)

efficiency which might have contributed for higher nutrient uptake. The same is also reported earlier by Omraj *et al*. (2007). Higher phosphorous uptake was also observed in sole blackgram (15.63kg ha^{-1}), which on par with finger millet + blackgram row ratio of 1:1 and 2:1 (14.45 kg ha^{-1} and 14.18 kg ha^{-1}, respectively) (Table 4). Higher K uptake was also observed in sole blackgram (34.00 kg ha1), followed by finger millet + blackgram row ratio of 1:1 and 2:1 (32.29 kg ha^{-1} and 31.71 kg ha^{-1}, respectively). Increased population of blackgram and less competition for nutrients and also less nutrient losses in K besides, blackgram can also

TABLE 5

Economics of finger millet + blackgram intercropping system under different methods of establishments

Treatments	Cost of cultivation (Rs.ha^{-1})	Gross returns (Rs.ha^{-1})	Net returns (Rs.ha^{-1})	B:C
T_1	24,379	66080	41701	1.71
T_2	15,663	60620	39100	1.82
T_3	25,357	54320	28963	1.14
T_4	24,990	51000	26010	1.04
T_5	24,772	61060	36288	1.46
T_6	24,646	70510	45864	1.86
T_7	21,520	51840	36177	2.31
T_8	15,663	50560	34897	2.23
T_9	23,388	46860	23472	1.00
T10	22,569	47700	25131	1.11
T11	22,378	53850	31472	1.41
T12	22,267	59800	37533	1.68
S.Em.±	-	2972.70	2972.70	0.13
CD (p=0.05)	-	6248.61	6248.61	0.28

compete for K uptake significantly. Potassium has a key role in activation of enzymes, photosynthesis and protein metabolism. The continuous availability of K and higher efficiency resulted in more uptake of potassium as compared to recommended doses. Similar results were reported earlier by Lingaraju *et al*. (2007).

V. Economics of Finger millet+Blackgram intercropping

Effect of finger millet + blackgram intercropping system and their interaction effects on cost of cultivation, gross returns, net returns and B:C ratio were reported in Table 5.

Maximum cost of cultivation of Rs.25,357 ha^{-1} was recorded with transplanted method of establishment in 1:1 row proportion and lowest was recorded in sole early sown blackgram (Rs.15,663 ha^{-1}). Gross returns differed significantly due to intercropping of blackgram in finger millet as well as method of establishment. Significantly higher Gross returns was recorded with transplanted finger millet + blackgram 4:1 row proportion (Rs.70,510 ha^{-1}) and lowest gross returns was recorded with direct sown finger millet + blackgram 1:1 row proportion (Rs.46,860 ha^{-1}). Net returns differed significantly due to intercropping of blackgram in finger millet as well as method of establishment. Significantly higher net returns was recorded with transplanted finger millet + blackgram 4:1 row proportion (Rs.45,864 ha^{-1}) and lowest net returns was recorded with direct sown finger millet + blackgram 1:1 row proportion (Rs.23,472 ha^{-1}). B:C differed significantly due to intercropping of blackgram in finger millet. Higher B:C is recorded in direct sown sole finger millet (2.31) and the lowest B:C was recorded with Transplanted finger millet + blackgram 2:1 row proportion (1.04) (Table 5).

REFRENCES

ANCHAL DASS AND SUDHISHRI, 2008, Intercropping in finger miller (*Eleusine corocana*) with pulses for enhanced productivity, resource conservation and soil fertility in uplands of Southern Orissa. *Indian. J. Agron.,* **55** (2) : 89 - 94.

DUTTA, D. AND BANDOPADYAY, P., 2006, Production potential of intercropping of ground nut with pigeon pea and maize under various row proportions in rain fed *Alfisol* of West Bengal. *Indian J. Agron.,* **51** (2) : 103 - 106.

The Mysore Journal of Agricultural Sciences

LINGARAJU, B. S., MARER, S. B. AND CHANDRASHEKAR, S. S., 2007, Studies on intercropping of maize and pigeonpea under rainfed conditions in northern transitional zone of Karnataka. *Karnataka J. Agric. Sci.,* **21** (1) : 1 - 3.

MOHAN KUMAR, R., GIRIJESH, G. K., KRISHNA MURTHY, N., REDDY, V. C. AND VAGEESH, T. S., 2012, Yield potential, biological feasibility and economic viability of maize (*Zea mays* L.) and local fieldbean (*Dolichos lablab* L.) inter cropping system in southern transitional zone of Karnataka. *World Res. J. Agron*., **1** : 4 - 6.

OMRAJ, M., KHAFI, H. R., SHEKH, M. A., ASHA, C., MEHTA AND DAVDA, B. K., 2007, Effect of vermicompost and nitrogen on content, uptake and yield of *rabi* maize. *Crop Res.,* **33** (2 & 3) : 53 - 54.

UMMED SINGH, SAAD, A. A. AND SINGH, S. R., 2008, Production potential, biological feasibility and economic viability of maize based inter cropping system under rain fed conditions of Kashmir valley. *Indian J. Agric. Sci*., **78** (12) : 1023 - 1027.

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