Mysore J. Agric. Sci., 54 (3) : 73-79 (2020)

Studies on Intercropping in Finger Millet (*Eleusine coracana* L.) under SRI Principles

K. Abinaya, S. Natarajan, M. Ganapathy and K. Arivazhagan
Department of Agronomy, Faculty of Agriculture, Annamalai University, Chidambaram, Tamil Nadu - 608 002
e-Mail: vspnat@gmail.com

Abstract

Thirteen treatments of sole crops and intercropping system *viz*., Sole finger millet (T_1), Sole soybean (T_2), Sole blackgram (T_3), Sole greengram (T_4), Finger millet + blackgram 1:1 (T_5), Finger millet + blackgram 2:1 (T_6), Finger millet + blackgram 1:2 (T_7), Finger millet + greengram 1:1 (T_8), Finger millet + greengram 2:1 (T_9), Finger millet + greengram 1:2 (T_{10}), Finger millet + soybean 1:1 (T_{11}), Finger millet + soybean 2:1 (T_{12}) and Finger millet + soybean 1:2 (T_{13}) were evaluated in a randomized block design with three replications. Grain and straw yield were significantly higher in sole finger millet (4320 and 6676 kg per ha, respectively) and it was followed by finger millet + blackgram (or) greengram at 2:1 (3991 and 6287 kg per ha, respectively). In intercropping, seed and haulm yield were significantly higher in (949 and 2249 kg respectively) sole blackgram followed by (441 and 1394 kg per ha, respectively) blackgram + finger millet at 1:2. Blackgram and greengram were at par with each other. The highest gross income (Rs.220055), net income (Rs.164144) and benefit cost ratio (3.93) were significantly recorded in finger millet + blackgram at 2:1. LER (1.12), ATER (1.06), IER (1.12) and finger millet equivalent yield (4521 kg per ha) were significantly highest in finger millet + blackgram at 2:1. Though intercropping resulted in significant reduction in the yield of sole crops, it was compensated by components crops in terms of LER, ATER, IER, finger millet equivalent yield and income.

Keywords: Finger millet, Intercropping, Yield, Cropping indices, Economics (Footnotes)

Millets are cultivated mainly as rainfed crop, and it succeeds under stressful situation where other crops fail to produce an acceptable harvest. Millets are important staple food crops to the millions of people in the arid and semi-arid regions of the world due to their greater resistance to pests and diseases and good adaptation to a wide range of environments. Government has notified 2018 as 'National Year of Millets' to boost production of the nutrient-rich millets.

Finger millet (*Eleusine coracana* L.) is one of the important millet crops in India, next to sorghum and pearl millet (Dass *et al*., 2013). It contains 9.2 per cent protein, 1.3 per cent fat, 76.3 per cent carbohydrates, 2.2 per cent minerals and 3.9 per cent ash besides vitamin A and B. (Tomar *et al*., 2011).

The ideas and methods of the system of rice intensification (SRI) which is improving irrigated rice production are now adapted to many other crops: wheat, maize, finger millet, sugar cane, mustard, legumes, and even spices. Promoting better root growth and enhancing the soil fertility with organic materials are being found effective means for raising the yields of many crop plants with less water, less fertilizer, reduced seeds, fewer agro chemicals, and greater climate resilience (Prabhakar Adhikari *et al.,* 2017). In 2011-2012, the system of wheat intensification (SWI) produced yield of 7.93 t / ha which was 30 per cent higher than for standard recommended practices (SRPs); in 2012-2013 (climatically a less favorable year), SWI relatively yielded better by 46 per cent under climatic stress. SWI produced 12.5 per cent less in the stressful year, while the reduction for the SRPs ranged from 18 per cent to 31 per cent (Anil Kumar *et al*., 2015). Application of SRI method has been shown to improve finger millet grain yield significantly while reducing cost (Mukherjee *et al.,* 2012). Integrating different spacing between plants to have varied plant density with diverse sources of nutrient under SRI would be of agronomic importance in augmenting the yield of finger millet.

Intercropping is a potentially beneficial system which shows substantial yield advantage over sole cropping and reduced risk, 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. In this context inter cropping finger millet and legumes would be a better option to enhance the yield as well as the economic livelihood of the farmers.

Material and Methods

A field investigation was carried out at Pandilingapuram village, Erode district during December to April (Marghazipattam) for two consecutive years during 2016 and 2017 using Co 15 variety of finger millet, VBN 2 variety of blackgram and greengram and Co 3 variety of soybean in 1:1, 2:1 and 1:2 additive series. It was laid out in randomized block design with thirteen treatments replicated thrice. The experimental site was shallow soil type having pH 8.2, low in organic carbon (0.41%), low in nitrogen (185 kg/ha), medium in phosphorus (8.3 kg/ha) and rich in potassium (320 kg/ha). The crops were transplanted on 20th January, 2017 and that of blackgram, greengram and soybean were sown on 21st January, 2017. The corresponding dates for the second trial was 18th January and 19th January, 2018, respectively. A spacing of 30 cm x 30 cm was followed for sowing of sole as well as intercropped finger millet. For blackgram and greengram as a sole crop, spacing of 30 cm x 10 cm was followed and for soybean 30 cm x 5 cm was followed. In intercropping systems for both crops, fertilizers were applied based on recommendations of main crop of finger millet. For sole crop of finger millet, fertilizers were applied @ 60:30:30 kg NPK/ha. The 2/3 of Nitrogen and entire Phosphorus and Potassium was applied at the time of sowing through Urea, Diammonium-phosphate and Muriate of potash. The remaining Nitrogen was applied in two equal splits. Weeds were controlled manually by giving two hand weeding. The crop was given with adequate amount of irrigation at the time of transplanting. Subsequent irrigation was given when soil developed fine cracks. Observations on growth and yield attributes of both main and intercrops were taken at appropriate time. Finger millet was harvested on 27th April, 2017 and 28th April, 2018 and that of blackgram and greengram were harvested on 22nd March, 2017 and 24th March, 2018. Soybean was harvested on 12th April, 2017 and 14th April, 2018 respectively for two trials. Economics was calculated according to the market price of each crop.

Results and Discussion

Effect of Intercrops on Finger Millet

All the growth parameters of finger millet *viz.,* plant height, root length, root volume, leaf area index (LAI) and dry matter production (DMP) were significantly influenced by different intercrop ratios. Finger millet when grown as a sole crop excelled over all the other intercrop situations as indicated by significantly higher values are recorded. Next to sole finger millet, blackgram (or) greengram intercropped with finger millet at 2:1 performed significantly higher than the rest of the treatments.

Finger millet recorded the maximum plant height of 118.13 cm and was higher by 5.84 per cent compared to blackgram at 2:1, and greengram did not differ in its performance compared to blackgram. Intercropping soybean with finger millet was observed to be more competitive than that of blackgram and greengram at relative plant ratios and it has been very much reflected from the lower value obtained from the plots where soybean was intercropped. Another interesting observation is that, increase in intercrop plant density from 2:1 through 1:1 to 1:2 showed higher competitiveness with finger millet irrespective of intercrops *viz.,* blackgram, greengram and soybean, indicating that intercrop density above certain extent is not advisable. Padhi *et al.* (2010) and Poornima (2009) reported the necessity of optimum utilization of resources to achieve maximum yield and for that, optimum plant population of main crop or optimum row ratio of main and component crop in the intercropping systems played a major role. At harvest, DMP of sole finger millet was 9722 kg/ha, which was higher by 1333 kg compared to finger millet + blackgram

TABLE 1

Growth parameters of finger millet as influenced by different intercropping systems

Treatments	Plant height (cm)	Root length (cm)	Root volume (cc)	LAI at 50% flowering	Dry matter production (kg/ha)
T_1 - Finger millet sole planting	118.13	37.94	13.25	5.41	9722
T_2 - Soybean sole planting	-	-	-	-	-
T_3 - Blackgram sole planting	-	-	-	-	-
T_4 - Greengram sole planting	-	-	-	-	-
T_5 - Finger millet + Blackgram (1:1)	100.72	29.49	10.43	4.26	7082
T_6 - Finger millet + Blackgram (2:1)	111.22	31.20	11.46	5.03	8389
T_7 - Finger millet + Blackgram (1:2)	92.42	27.72	9.07	3.74	5997
T_8 - Finger millet + Greengram (1:1)	99.30	29.36	10.37	4.21	7008
T_9 - Finger millet + Greengram (2:1)	109.97	31.13	10.08	4.81	8104
T_{10}- Finger millet + Greengram (1:2)	90.57	27.64	9.21	3.59	5756
T_{11}- Finger millet + Soybean (1:1)	92.31	27.71	9.34	3.80	6907
T_{12}- Finger millet + Soybean (2:1)	103.11	29.19	11.31	4.12	7220
T_{13}- Finger millet + Soybean (1:2)	88.75	26.66	8.88	3.24	5315
S.Ed	3.28	0.70	0.32	0.15	340.73
CD (P = 0.05)	6.77	1.46	0.66	0.31	701.91

(or greengram) at 2:1, 2640 kg with finger millet + blackgram (or greengram) at 1:1 and by 2502 kg with finger millet + soybean 2:1. The poorest performance was with soybean 1:2, indicating its more dominant nature as it is conspicuous from intercropping indices (Table 1). Several authors reported varying competitive nature of intercrops with different proportion as observed in the present study. Pradhan *et al.* (2014) reported that the growth parameters were comparatively higher in sole finger millet compared to finger millet + niger due to higher competition between plants in search of light.

The increase in grain yield due to various treatments could be attributed to proportionate increase in yield attributing parameters such as number of fingers/ear head, number of ear head/plant, number of grains/ear head and length of ear head; though test weight did not contribute to the yield differences. Sole planting of finger millet demonstrated significantly the highest values in all the yield parameters observed, the grain weight/m^2 being 568.43g compared to its intercropping with blackgram (or greengram) at 2:1 stand (538.01g). At the same intercropping ratio, however, soybean reduced the grain weight of the finger millet significantly (393.76 g) thus clearly demonstrating the unbefitting combination of soybean and finger millet in the study. As observed with growth contributing parameters, yield attributing factors reflected a more or less similar trend as yield is only the manifestation of growth. Performance of crops in pure stand compared to its intercropping stand may be attributed to the absence of interspecific competition and limited distribution of habitat having more photosynthetic efficiency, better light interception, higher dry matter accumulation and translocation of manufactured food material from the source (vegetative parts) to sink (reproductive organ by seed) as reported by Parvender Sheoran *et al.* (2010) in maize + blackgram intercropping system (Table 1). Identically, Kadam *et al.* (2017) who declared that sole finger millet recorded higher ear length compared to other intercropping treatments due to better growth attributes *viz.,* plant height, leaf area index, dry matter production and its distribution and this report aid our present conclusions.

TABLE 2

Yield and Yield parameters of finger millet as influenced by various intercropping systems

Treatments	No of fingers/ear head	No of ear head/m²	No of grains/ ear head	Grain weight/m²	Length of ear head (cm)	Test Weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest Index (%)
T1 - Finger millet sole planting	11.25	54.43	4000	568.43	10.34	2.61	4320	6676	39.28
T2 - Soybean sole planting	-	-	-	-	-	-	-	-	-
T3 - Blackgram sole planting	-	-	-	-	-	-	-	-	-
T4 - Greengram sole planting	-	-	-	-	-	-	-	-	-
T5 - Finger millet + Blackgram (1:1)	9.37	48.04	3739	483.51	8.66	2.60	3217	5217	38.14
T6 - Finger millet + Blackgram (2:1)	9.94	51.78	3918	538.01	9.74	2.60	3991	6287	38.83
T7 - Finger millet + Blackgram (1:2)	8.82	45.75	3589	430.35	7.85	2.61	2582	4344	37.27
T8 - Finger millet + Greengram (1:1)	9.34	48.16	3700	476.66	8.55	2.61	3096	4958	38.44
T9 - Finger millet + Greengram (2:1)	9.85	51.25	3849	524.19	9.48	2.61	3896	6193	38.61
T10 - Finger millet + Greengram (1:2)	8.83	44.98	3539	419.35	7.68	2.61	2525	4327	36.85
T11 - Finger millet + Soybean (1:1)	8.84	45.49	3650	441.73	7.91	2.61	2748	4385	38.52
T12 - Finger millet + Soybean (2:1)	9.38	48.75	3789	498.85	8.93	2.60	3551	5688	38.43
T13 - Finger millet + Soybean (1:2)	6.58	44.41	3479	393.76	6.85	2.60	2184	3787	36.57
SEd	0.17	1.05	180.85	12.28	0.18	2.06	158.83	258.63	2.65
CD (P=0.05)	0.37	2.17	372.56	25.31	0.38	NS	327.21	532.78	5.47

The grain as well as straw yield of finger millet varied significantly due to different intercropping treatments. The highest grain (4320 kg/ha) and straw yields (6676 kg/ha) was recorded with sole finger millet and this was higher by 8.24 per cent compared to finger millet + blackgram (or) green gram at 2:1 and the corresponding yield increase over with 1:1 and 1:2 is 34.28 and 67.31 per cent, respectively which could be attributed to optimum plant densities in sole cropping system. It is also observed that even with half of the population of finger millet, both blackgram and greengram reduced the yield of the main crop and the reduction is more with soybean as intercrop. Among the intercrops and row ratios, finger millet + soybean at 1:2 recorded the lowest grain yield of 2184 kg/ha (Table 2). Many authors reported higher competition offered by intercrops for natural resources like space, plant nutrient, moisture and incoming sun radiation for pearl millet with greengram, cluster bean and moth bean at 1:2 (Baldevram *et al.,* 2005; Kumar *et al.,* 2006; Choudhary, 2009).

Economics and Yield Advantages of Intercropping

Finger millet + blackgram (2:1) recorded the highest gross income (Rs.220025), net income (Rs.164144) and benefit cost ratio (3.93) compared to sole finger millet and this may be attributed due to higher grain yield and good market price (Table 3). The results are in line with the findings reported by Marer (2005) and Girase *et al*. (2007).

Finger millet intercropped with blackgram, greengram and soybean increased the Land equivalent ratio (LER), Area time equivalent ratio (ATER) and Income equivalent ratio (IER) compared to sole cropping. The highest LER (1.12), ATER (1.06) recorded in finger millet + blackgram at 2:1 may be due to additional yield obtained from intercrop and makes the combination highly advantageous over sole cropping. The maximum IER (1.12) was recorded in finger millet + blackgram at 2:1 compared to sole crop implying that 12 per cent more land would be required as sole crops to produce the yield obtained under intercropping situations. LER does not take into account the time for which land is occupied by the component crops of an intercropping system. It was revealed that ATER in all the intercropping systems was smaller than LER indicating the over estimation of resource utilization in the later. Among the intercrops, soybean with finger millet combination recorded lowest ATER due to longer duration of soybean compared to blackgram and

TABLE 3

Economics and yield advantages of various treatments

Treatments	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C Ratio	LER	ATER	IER	FMEY
T1 - Finger millet sole planting	57685	216000	158314	3.74	-	-	-	4320
T2 - Soybean sole planting	30705	33180	2474	1.08	-	-	-	-
T3 - Blackgram sole planting	32396	99645	67248	3.07	-	-	-	-
T4 - Greengram sole planting	31970	63291	31320	1.97	-	-	-	-
T5 - Finger millet + Blackgram (1:1)	54520	191090	136569	3.50	1.04	0.95	1.04	3821
T6 - Finger millet + Blackgram (2:1)	55880	220025	164144	3.93	1.12	1.06	1.12	4400
T7 - Finger millet + Blackgram (1:2)	55678	175405	119726	3.15	1.06	0.92	1.06	3508
T8 - Finger millet + Greengram (1:1)	55628	175240	119611	3.15	1.01	0.92	1.01	3504
T9 - Finger millet + Greengram (2:1)	55749	207429	151679	3.72	1.08	1.03	1.08	4148
T10 - Finger millet + Greengram (1:2)	55608	158224	102615	2.84	1.05	0.91	1.05	3164
T11 - Finger millet + Soybean (1:1)	56786	143196	86409	2.52	0.81	0.78	0.81	2863
T12 - Finger millet + Soybean (2:1)	56947	183136	126188	3.21	0.99	0.96	0.99	3662
T13 - Finger millet + Soybean (1:2)	56564	125034	68469	2.21	0.98	0.90	0.98	2500

The Mysore Journal of Agricultural Sciences

greengram. Earlier studies have reported that the greater value of LER indicated greater biological efficiency of crops grown in association and was probably due to temporal and spatial complementary effect and thereby giving corresponding yield advantages. Dutta and Bandopadyay (2006) observed that intercropping system achieved more LER compared to sole crop which may due to combined effect of better utilization of growth resources than sole cropping of component crops resulting in higher productivity per unit area.

Apart from the competitive effects, prevailing price become an additional important factor in choosing the components of intercropping system and so intercrop yields were converted into finger millet equivalent yield added with finger millet grain yield. Finger millet + blackgram at 2:1 recorded the maximum (4400 kg) finger millet equivalent yield, due to additional advantage of inter crop yield and higher yield of finger millet with blackgram and also the higher market price of blackgram (Rs.105) compared to greengram (Rs.73) and soybean (Rs.42). There was an increase of 15.15 and 25.42 per cent respectively compared to 1:1 and 1:2 (Table 3).

The data indicated that intercropping of finger millet + blackgram at 2:1 recorded higher LER, ATER, IER, finger millet equivalent yield, net income and benefit cost ratio than that of sole crop, other intercrops like greengram and soybean and also other ratios like 1:1 and 1:2. Finally, Finger millet + blackgram at 2:1 were proved as the best combination for improving productivity and profitability.

REFERENCE

ANIL KUMAR, RISHI RAJ, SHIVA DAR AND PANDEY, U.C., 2015, Performance of system of wheat intensification (SWI) and conventional wheat sowing under north eastern plain zone of India. *Annals of Agricultural Research,* **36**(3) : 258 - 262.

BALDEVRAM, G. R., CHOUDHARY, JAT, A. S. AND JAT, M. L., 2005, Effect of integrated weed management and intercropping systems on growth and yield of pearl millet (*Pennisetum glaucum*). *Indian Journal of Agronomy*, Vol. **50** (3) : 210 - 213.

CHOUDHARY, R. A., 2009, Intercropping in pearl millet (*Pennisetum glaucum* L.) R. Br. Emend. Stuntz with pulse crops in rainfed conditions, *M.Sc. (Agri.). Thesis,* Sardarkrushinagar Dantiwada Agricultural University., Sardarkrushinagar, Gujarat, India.

DASS, A., S. SUDHISHRI AND LENK, N. K. , 2013, Integrated nutrient management to improve finger millet productivity and soil conditions in hilly region of eastern India. *J. Crop Improve.,* **27** (5) : 528 - 546.

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

KADAM. V. L., OLOWE, J. S. AJAYI AND OGUNBAYO, O. A., 2017, Potential of intercropping soybean and cowpea with sunflower in the transition zone of South West Nigeria. *Tropical Agric. Res. and Ext.,* **6** : 91 - 102.

KUMAR, R., NANWAL, R. K. AND HOODA, R. S., 2006, Crop productivity and soil health as influenced by pearl millet and legume inter and strip cropping system in sandy loam soils. *Journal of Maharashtra Agricultural University*, **33** (3) : 295 - 29.

MUKHERJEE, K., GAHOI, S. AND SINHA, B., 2012, Promotion of SRI-millet: reopening a closed chapter. *International Journal of Agricultural Innovative Research*, **3** : 812 - 816.

PADHI, A. K., PANIGRAHI, R. K. AND JENA, B.K., 2010, Effect of planting geometry and duration of intercrops on performance of pigeonpea - finger millet intercropping systems. *Indian J. Agric. Res.,* **44** (1) : 43 - 47.

PARVENDER SHEORAN, VIRENDERSARDANA, SUKHVINDER SINGH AND BHARAT BHUSHAN, 2010, Bio-economic evaluation of rainfed maize based intercropping systems with black gram under different spatial arrangements. *Indian Journal of Agricultural Sciences*, **80** (3) : 277 - 247.

POORNIMA, D. S., 2009, Studies on feasibility of transplanting pigeonpea in sole cropping and finger millet based intercropping system. *M.Sc. (Agri.) Thesis,* UAS, Bengaluru.

PRADHAN, K. N. AND SADHU, A. C., 2014, Performance of summer pearl millet based intercropping with legume crops in different row ratios under middle gujarat conditions. *Int. J. Agric. Sci.,* **9** (2) : 510 - 512.

PRABHAKAR ADHIKARI, HAILU ANYA, GERALD ARUNA, ARUN BALAMALTI, SOUMIK BANERJEE, BASKARAN, P., BARAH, B. C., DEBARAJ BEHERA, TAREKE BERHE, PARAG BORUAH, SHIVA DHAR, SUE EDWARDS, MARK FULLORD, BIKSHAM GUJJA, HAROUNA IBRAHIM, HUMAYUN KABIR, AMIR KASSAM, RAM, KHADKA, B., KOMA, Y. S., NATARAJAN, U. S., RENA PEREZ, DEBASHISH SEN, ASIF SHARIF, GURPREET SINGH, ERIKA STYGER, AMOD, K., THAKUR, ANOOP TIWARI, NORMAN UPHOFF AND ANIL VERMA, 2017, System of crop intensification for more productive, resource-conserving, climate-resilient. and sustainable agriculture: experience with diversecrops in varying agro ecologies. *International Journal of Agricultural Sustainability*, pp. 1 - 28.

TOMAR, G. S., TANUK, S. K. AND CHOUDHARY, J. L., 2011, Science of crop production part-1 *kharif* crop. Kushal publication, Varanasi, India, pp.182 - 183.

(*Received :* June, 2020 *Accepted :* August, 2020)