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Competition Indices and Energetics of Rain Fed Millet based Cropping System

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ABSTRACT: A field experiment was conducted in the Regional Research Transfer & Technology Station at Semiliguda under rainfed condition during 2019 & 2020. The soil of the experimental site was sandy clay loam with pH 5.06, organic carbon 5.03 g/kg, available N 372 kg/ha, P 33.2 kg/ha and K 313.0 kg/ha. The experiment was laid out in a randomized complete block design with twelve treatments and four replications. The treatments were, finger millet(sole), little millet (sole), redgram (sole), blackgram (sole), fingermillet - horsegram, little millet- horsegram, fingermillet + redgram (4:2), littlemillet + redgram(4:2), finger millet + black gram(4:3), little millet + black gram(4:3), finger millet + black gram (4:3) -horsegram, little millet + black gram(4:3)-horsegram. Highest FMEY was recorded under little millet + Blackgram (4:3)-horsegram system (3153 kg/ha) followed by little millet – horsegram system (2842kg /ha), which is at par, but significantly higher than all other. FM + BG (T_7) recorded significantly higher mean land equivalent ratio (LER, 1.35). The highest total RCC was in finger millet + red gram intercropping (4.54). Competition ratio (CR) of cereals and legumes maintained an inverse relationship. Among red gram intercropping system partial aggressivity (A) value of red gram and main crops are positive. But among black gram intercropping system partial aggressivity (A) value of black gram was positive and value of finger millet was negative. Maximum land use efficiency (LUE) of 46.58% was estimated in three systems, FM + RG (T_7), LM + RG (T_8) and sole RG (T_3). The highest energy input was recorded to be 11.7 GJ/ha in FM + BG –HG system (T_{11}) followed by 9.19 GJ/ha in LM+ BG – HG system (T_{12}). The highest total energy output was 46.6GJ/ha in LM+BG-HG (T_{12}). Maximum nutrient use efficiency (NUE) was estimated in sole little millet system (T_2, 45.33 kg). Higher energy output, net energy, energy efficiency was noticed in LM + BG – HG system (T_{12}), which was due to higher system yield and gross return of the system.

Keywords: Intercropping, FMEY, Energetics, land equivalent ratio (LER), RCC, Agressivity, competitive ratio (CR).

INTRODUCTION

Millets are small-seeded coarse cereals that are commonly grown in tropical and desert climates. They are members of the Poaceae family. Minor millets were significant food crops in the past and are now hailed as the foods of the future due to their resilience to the negative impacts of climate change and global warming. Millets are more noticeable in delicate ecological settings and are frequently cultivated in a variety of soil types, severe environments, and resource shortages. Compared to many other crops, millets produce a more consistent harvest, making them significant crops for food and feed. Millions of smallholders in arid regions and domestic animals may be able to get food and feed from these, which can be modified to a wide range of temperature, moisture regime, and input conditions. Increasing the cultivable area and crop productivity are the general ways to increase production. As the population increases rapidly, the resources are depleted; hence, these considerations are less important. There should be focus on cropping system approach for increasing pulse production per unit time and space (Reddy and Reddy 2013). Intercropping of sweet potato with cereals, millets and pulses could act as contingent crop and increase land use efficiency apart from augmenting farm yield in upland rainfed conditions (Nedunchezhiyan, 2011). The interaction due to different crops in a sequential cropping system occurs on resources like soil, residual moisture, light, nutrients. The crops efficiently utilize the nutrients and moisture left over by the previous crop. They efficiently utilize the light as they cover the land very quickly due to change in growing and rooting pattern (Singh *et al.*, 2009).

MATERIALS AND METHOD

A field experiment was conducted in the Regional Research Transfer & Technology Station at Semiliguda under rainfed condition during 2019 & 2020. The soil

of the experimental site was sandy clay loam with pH 5.06, medium in organic carbon 5.03 g/kg, medium in available N 372 kg/ha, medium in P 33.2 kg/ha, high in K 313.0 kg/ha and S 10.5 ppm. The experiment was laid out in a randomized complete block design with twelve treatments and four replications. The treatments were, finger millet(sole), little millet(sole), red gram (sole), black gram (sole), finger millet - horsegram, little millet- horsegram, finger millet + red gram (4:2), little millet + red gram(4:2), finger millet + black gram(4:3), little millet + black gram(4:3), finger millet+ black gram (4:3) -horsegram, little millet + black gram(4:3)-horsegram. Variety 'Arjun' of finger millet, 'Sabara' of little millet, 'Ujala' of black gram, 'PRG-176' of pigeon pea and 'Kala kolatha' local variety of horse gram were used in this experiment. Geographically, this experimental site falls under Eastern Ghat High Land zone of Odisha. Having red laterite soil and is located at 18^0 42' N latitude and 82^0 30' E longitudes and at an elevation of 884.0 meters above mean sea level. Finger millet as the main crop and black gram and red gram as inter crops were sown during rainy season. Finger millet and little millet were sown with a spacing of 20cm × 10cm and seed rate of 10 kg ha^{-1}. Red gram with spacing of 60cm × 30 cm and seed rate of 15 kg ha^{-1} for sole crop and as inter crop with the seed rate @ 11 kg ha^{-1}, black gram was sown with spacing of 30 cm x 10cm and seed rate of 15 kg ha^{-1} for sole crop and as inter crop seed rate @ 8.4 kg ha^{-1}. Millet plant population was 50%. In case of inter crop red gram plant population was 75% and black gram population was 56% per cent of normal sole cropping. During post rainy season, horse gram was sown as sole crop with a row spacing of 30 cm and the intra-row spacing of 10 cm was maintained by thinning operation 20 days after sowing. The crop was sown after cultivating the plots with a seed rate of 15 kg ha^{-1}. Line sowing was doneusing trench hoe and seeds were covered with soil after sowing. FYM @ 5 t ha^{-1} was applied at the time of last ploughing as per the treatment. In case of finger millet, little millet, red gram, black gram fertilizer applied @40:15:15, 20:7.5:7.5, 20:30:30 & 20:30:30(N: P_2O_5: K_2O) kg ha respectively. Full dose of P, K & 50% N were applied as basal and rest 50% N were applied to the crop at first & second earthing up, respectively. The intercropping systems were evaluated in terms of finger millet equivalent yield (q/ha), system productivity (kg/ha/day) and economic returns. Economic returns (Rs/ha) for individual crop in intercropping system were calculated on the basis of prevailing market rates of inputs and selling of produce. The system productivity was calculated by converting the yield of all crops grown in intercroppingsystem in terms of finger millet equivalent yield in kg/ha and dividing it with the duration of intercropping system. It was expressed as kg/ha/day. Yield of individual crop was converted into equivalent yield (q/ha) on the basis of prevailing market price of the crop. It was calculated by the following formula:

$$\text{FMEY (kg ha}^{-1}) = \frac{\text{Yield of inter crop (kg ha}^{-1}) \times \text{Price of inter crop (kg ha}^{-1})}{\text{Price of finger millet (Rs kg}^{-1})}$$

The land equivalent ratio (LER), relative crowding coefficient (RCC), aggressivity (A), competition ratio (CR) were worked out as per the method given by Willey (1980), Willey (1979), Mc Gilchrist, (1965), Willey and Rao (1980), respectively. The energy output: input ratio and energy productivity were calculated using the following equations (Rafiee *et al.*, 2010). The partial factor productivity (PFP_N) was calculated using the formula of (Ladha *et al*., 2005). Land use efficiency was calculated as total duration of a cropping system in the field expressed as percentage of number of days in a year.

$$\text{LUE} = \frac{\text{Total duration of a system (day)}}{365} \times 100$$

RESULTS AND DISCUSSION

Grain yield of a crop or cropping system is the final indicator for evaluating the superiority of the treatment. Inclusion of legumes like black gram as intercrop or horsegram as sequence crop with LM and FM has additive effect over the yield of base crop as well as succeeding crop (Table 1). It enhanced the productivity and profitability of the system. Considering the total system, highest FMEY (3144 kg/ha) was recorded under LM + BG - HG system (T_{12}) which was on par with that of T_6 in LM - HG system (2854 kg/ha) but significantly higher than all other systems *i.e.* FM + BG – HG system (T_{11}) followed by FM – HG (T_5), FM + RG (T_7) with FMEY of 2485 kg/ha, 2326 kg/ha and 2226 kg/ha respectively. However, sole BG recorded the lowest FMEY (1441 kg/ha).

Table 1: Finger millet equivalent yield of component crops in millet based cropping system.

Treatments		FMEY(kg/ha)														
		Kharif									Rabi			Total		
		Main crop			Inter crop			Total			Sequence crop			System		
		2019	2020	Mean	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean
T_1	FM (Sole)	1606	1674	1640	-	-	-	1606	1674	1640	-	-	-	1606	1674	1640
T_2	LM (Sole)	1758	1868	1813	-	-	-	1758	1868	1813	-	-	-	1758	1869	1813
T_3	RG (sole)	1620	1711	1666	-	-	-	1620	1711	1666	-	-	-	1620	1711	1666
T_4	BG (Sole)	1431	1452	1441	-	-	-	1431	1452	1441	-	-	-	1431	1452	1441
T_5	FM - HG	1610	1659	1635	-	-	-	1610	1659	1635	679	705	692	2289	2364	2326
T_6	LM – HG	1723	1938	1831	-	-	-	1723	1938	1831	1017	1031	1024	2740	2969	2854
T_7	FM + RG(4:2)	928	956	942	1259	1309	1284	2187	2265	2226	-	-	-	2187	2265	2226
T_8	LM + RG(4:2)	1078	1079	1078	695	727	711	1773	1805	1789	-	-	-	1773	1805	1789
T_9	FM + BG(4:3)	870	894	882	858	920	889	1728	1814	1771	-	-	-	1728	1814	1771
T_{10}	LM + BG(4:3)	1081	1087	1084	874	933	904	1955	2020	1988	-	-	-	1955	2020	1987
T_{11}	FM + BG(4:3)-HG	865	890	878	890	928	909	1755	1818	1787	681	716	699	2437	2534	2485
T_{12}	LM + BG(4:3)-HG	1118	1133	1126	931	967	949	2049	2100	2075	1064	1076	1070	3113	3176	3144
SEm(+)		-	-	-	-	-	-	151	159	155	-	-	-	198	215	205
CD (P=0.05)		-	-	-	-	-	-	444	467	456	-	-	-	580	630	601

FM: Finger millet, LM: Little millet, RG: Red gram, BG: Black gram, HG: Horse gram

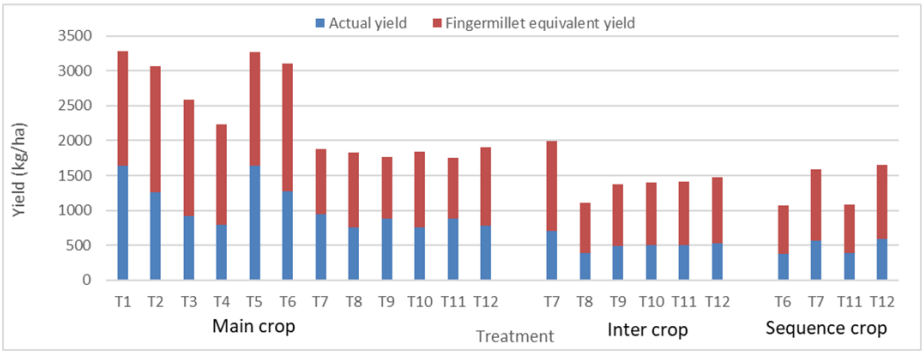

Fig. 1. Comparison between component crop and main crop equivalent yield in millet based cropping system.

Land equivalent ratio (LER). Land equivalent ratio (LER) reflects the biological efficiency of intercropping systems (Nedunchezhian *et al*., 2011). All intercropping treatments recorded the land equivalent ratio more than (1.0). Among the various cropping systems FM + BG (T_7) recorded significantly higher mean land equivalent ratio (1.35) which was 32 %, 17.3%, 15.3%, 10.6% and 5.4% higher than LM + RG (T_8), FM+ BG (T_9), FM + BG – HG(T_{11}), LM + BG (T_{10}) and LM + BG – HG(T_{12}), respectively. The obvious reason for yield advantage in inter cropping system was due to the fact that the component crops differed in utilization of growth resources and converting them more efficiently resulting in higher yield per unit area than that produced by sole crops as stated by Patil *et al.* (2010). Partial LER of intercropped pulse was more than millets but it was less in case of LM + RG (T_8) due to lower yield of pigeon pea in both the years for lodging effect of little millet over pigeon pea. Girase *et al.* (2007) noticed that pearl millet + moth bean (2:1) or pearl millet + cowpea (2:1) was the most productive, efficient, and profitable combination under rainfed conditions in the north Maharashtra. These findings were based on pearl millet equivalent yield, net monetary returns, and LER. In their research, Sharmili and Parasuraman (2018) showed that cultivating small millet and pigeonpea in a 6:1 row ratio with horsegram or moth bean in order was preferable than producing small millet as a solitary crop. In general, partial LER of all the crops in intercropping systems was more than 0.5, indicating that competitive pressures among the component crops were low and that both crops could be complementary in mixture (Njoku *et al*., 2007). The total LER was more than one in all the intercropping systems. When the LER is more than one, it indicates the greater biological efficiency of intercropping system and better use of environmental resources for plant growth. Higher yield advantage in intercropping system and their differences could be due to the component crops which differed in their use of growth resources and utilized them efficiently as it could be resulting in higher yields per unit area than that produced by their sole crops and also due to mutualistic and complementary effect of component crops in the system. The result as obtained in the present study was also documented in the studies made by Patil *et al.* (2010); Shwethanjali *et al.* (2018).

Relative crowding coefficient (RCC). Partial relative crowding coefficient (RCC) values of millets and intercrop were found to be more than one (Table 2). Among red gram inter cropping systems partial RCC value of red gram was found to be (2.24) higher than finger millet (2.02). It indicated that red gram was more competitive than finger millet. But partial RCC value of little millet (2.20) was higher than red gram (0.5) in little millet + red gram intercropping system. It indicated that little millet was more competitive than red gram. Among black gram inter cropping systems partial RCC value of black gram was found to be higher than finger millet in both inter cropping and horse gram taken as sequence crop after black gram + finger millet intercropping. It indicated that black gram was more competitive than finger millet. But partial RCC value of little millet was higher than black gram in little millet + black gram and horse gram taken as sequence crop after little millet + black gram intercropping system which showed that little millet was more competitive than black gram. RCC values of all component crops except red gram in little millet+ red gram inter cropping system were greater than one which indicated that all component crops and inter crops gave more yield than expected except red gram crop in little millet + red gram inter cropping. In little millet + red gram system RCC value was recorded less than one due to lower yield recorded in red gram because of lodging effect of little millet during vegetative stage of red gram in both the years. Total RCC value was also more than one and it ranged from 1.09 to 4.54 in various combinations of millet based intercropping. The highest total RCC was in finger millet + red gram intercropping (4.54). Similar yield advantage with high RCC was also observed in pigeonpea in an intercropping system with finger millet (Maitra *et al.*, 2001).

Aggressivity (A). Aggressivity (A) represents a simple measure of how much the relative yield increase in "a" crop is greater than that of "b" crop in an intercropping system (Nedunchezhiyan, 2011). Among red gram intercropping system partial aggressivity (A) value of red gram and main crops are positive. But among black gram intercropping system partial aggressivity (A) value of black gram was positive and value of finger millet was negative. It indicated that the finger millet was dominated crop and black gram was dominant crop. The main crop dominance depends on intercrops and agro-ecological situations (Aasim *et al.*, 2008). Legumes were more aggressive in intercropping system and tended to have depressing effect on finger millet (Maitra *et al.*, 2001).

Competition ratio (CR). Competition ratio (CR) is another index to measure competition in intercropping systems. It indicates the number of times by which one component crop is more competitive than the other in an intercropping system. It signifies the ratio of individual land equivalent ratios of the component crops and the proportion of component crops in the mixture. Higher CR values points towards more degree of competitiveness. Among black gram intercropping system CR values of black gram was higher than finger millet which indicated that the black gram was more competitive than finger millet. This might be due to higher LAI. But in LM based system LM was more competitive than black gram. Among RG intercropping system competition ratio of LM was highest (2.09) in LM+RG system (T8), which was due to lodging effect of LM over RG crop at vegetative stage during both the year. Both LM and FM are more competitive than RG. Layek *et al*. (2018) concluded that the CR of cereals and legumes maintained an inverse relationship.

Table 2: Land equivalent ratio (LER), Aggressivity (A), Competition Ratio(CR), Relative crowding co-efficient (RCC) of millet based cropping system.

Treatments		Land equivalent ratio			Aggressivity		Competition Ratio		Relative crowding co-efficient (RCC)		
		LERa	LERb	LER	AggA	AggB	CRa	CRb	Kab	Kba	K
T_1	FM (Sole)	-	-	-	-	-	-	-			
T_2	LM (Sole)	-	-	-	-	-	-	-			
T_3	RG (sole)	-	-	-	-	-	-	-			
T_4	BG (Sole)	-	-	-	-	-	-	-			
T_5	FM - HG	-	-	-	-	-	-	-			
T_6	LM – HG	-	-	-	-	-	-	-			
T_7	FM + RG(4:2)	0.57	0.77	1.35	0.121	0.291	1.12	0.89	2.02	2.24	4.54
T_8	LM + RG(4:2)	0.59	0.43	1.02	0.620	0.023	2.09	0.48	2.20	0.50	1.09
T_9	FM + BG(4:3)	0.54	0.62	1.15	-0.025	0.076	0.98	1.02	1.31	1.43	1.87
T_{10}	LM + BG(4:3)	0.60	0.63	1.22	0.076	0.052	1.07	0.93	1.67	1.49	2.49
T_{11}	FM + BG(4:3)-HG	0.54	0.63	1.17	-0.055	0.085	0.95	1.05	1.30	1.52	1.96
T_{12}	LM + BG(4:3)-HG	0.62	0.66	1.28	0.066	0.058	1.06	0.94	1.84	1.71	3.15

FM: Finger millet, LM: Little millet, RG: Red gram, BG: Black gram, HG: Horse gram

Land use efficiency (LUE). The LUE was mostly governed by duration of *rabi* crops. Total field duration of a cropping system expressed in percentage of 365 days was taken as the land use efficiency (LUE) of the system. Kumar *et al*. (2006); Patra *et al*. (2021) reported that variation in LUE was mostly governed by duration of the system. Maximum land use efficiency (LUE) of 46.58% was estimated in three systems, FM + RG (T_7), LM + RG (T_8) and sole RG (T_3). LUE was recorded to be highest in red gram based systems (46.58 %) because red gram crop occupied the land for maximum period (170 days) followed by FM - HG (155 days), little millet - horse gram (152 days), finger millet (95days), little millet (80 days) and black gram (80 days). Second highest LUE was estimated when HG crop was taken in sequence, which was 42.47% both in FM + BG - HG system (T_{11}) and FM - HG system (T_5) followed by LM + BG – HG system (41.64% in T_{12}) and LM - HG system (41.64% in T_{11}). LUE in FM + BG (T_9) and sole finger millet (T_1) was estimated to be 26.03%. However lowest LUE was estimated in sole little millet (T_2), sole black gram (T_4) and little millet + black gram (T_{10}) system (21.92%).

Table 3: Land use efficiency (LUE) & Nutrient use efficiency (NUE) of millet based cropping system.

Treatments		LUE			NUE (kg FMEY/kg nutrient added through fertiliser)		
		2019	2020	Mean	2019	2020	Mean
T_1	FM (Sole)	26.03	26.03	26.03	20.08	20.93	20.50
T_2	LM (Sole)	21.92	21.92	21.92	43.95	46.73	45.33
T_3	RG (sole)	46.58	46.58	46.58	20.25	21.39	20.83
T_4	BG (Sole)	21.92	21.92	21.92	17.89	18.15	18.01
T_5	FM - HG	42.47	42.47	42.47	19.08	19.70	19.38
T_6	LM – HG	41.64	41.64	41.64	34.25	37.11	35.68
T_7	FM + RG(4:2)	46.58	46.58	46.58	21.87	22.65	22.26
T_8	LM + RG(4:2)	46.58	46.58	46.58	22.16	22.56	22.36
T_9	FM + BG(4:3)	26.03	26.03	26.03	20.57	21.60	21.08
T_{10}	LM + BG(4:3)	21.92	21.92	21.92	30.55	31.56	31.05
T_{11}	FM + BG(4:3)-HG	42.47	42.47	42.47	19.65	20.44	20.04
T_{12}	LM + BG(4:3)-HG	41.64	41.64	41.64	29.93	30.54	30.23
SEm(±)		3.11	3.11	3.11	2.30	2.50	2.40
CD (P=0.05)		6.34	6.34	6.34	4.70	5.11	4.90

Nutrient use efficiency (NUE). Availability of nutrients in the soil solution and absorption capacity of plant decides the nutrient content in plants, which is ultimately manifested through crop yield. Nutrient removal by crop is directly related to the yield of the crop and nutrient content (Prakasha, 2017). Maximum nutrient use efficiency (NUE) was estimated in sole little millet system (T_2, 45.33 kg FMEY/ (20:7.5:7.5)kg N +P_2O_5+K_2O added) which was 27%, 45.9% and 47.9% higher than little millet - horse gram (T_6, 35.68 kg FMEY/ (30:30:20) kg N +P_2O_5+K_2O added) and LM + BG- HG (T_{12}, 30.23 kg FMEY/ (31:47:26)kg N +P_2O_5+K_2O added), respectively. Higher nutrient use efficiency was estimated in LM based system than FM based system due to addition of less nutrient in intercropping system, mutualism and complementary relationships between the intercrops which improve the main crop's yield characteristics with improved space utilisation, effective use of sunlight, nutrient and water. Legume effect also increases nitrogen efficiency.

Energetics. Total energy inputs in different cropping systems were in the range from 4.94 to 11.07 GJ/ha. The highest energy input was recorded to be 11.7 GJ/ha in FM + BG –HG system (T_{11}) followed by 9.19 GJ/ha in LM+ BG – HG system (T_{12}). This was mainly due to higher fertilizer dose *i.e.,* (40:15:15) kg N-P_2O_5- K_2O in finger millet than in little millet (20:7.5:7.5) kg N-P_2O_5-K_2O. The sole little millet cropping system required the lowest energy (4.94 GJ/ha) because of low input use. Among sole crops also highest energy input was recorded in finger millet (6.33 GJ/ha) due to use of higher fertilizer dose than all other crops. Total energy output was computed from main products and by-products of different cropping systems and it ranged from 23.4 GJ/ha in sole BG (T_4) to 46.6 GJ/ha in LM + BG - HG (T_{12}). The highest total net energy was estimated in LM + BG - HG (37.4 GJ/ha in T_{12}) and lowest in sole finger millet (17.8 GJ/ha in T_1). Energy productivity ranged from 526.4 KG/GJ in LM + RG (T_8,) to 763.5 KG/GJ in little millet + black gram (T_{10}).

Table 4: Energy input, Gross energy output & net energy of millet based cropping system.

Treatments		Energy input (GJ /ha)			Gross energy output (GJ/ha)			Net energy (GJ/ha)		
		2019	2020	Mean	2019	2020	Mean	2019	2020	Mean
T_1	FM (Sole)	6.33	6.33	6.33	23.6	24.6	24.1	17.3	18.3	17.8
T_2	LM (Sole)	4.94	4.94	4.94	25.8	27.5	25.2	20.9	22.5	20.3
T_3	RG (sole)	5.61	5.61	5.61	23.8	25.2	27.0	18.2	19.5	21.4
T_4	BG (Sole)	5.41	5.41	5.41	21.0	21.3	23.4	15.6	15.9	18.0
T_5	FM - HG	10.03	10.03	10.03	33.7	34.7	34.1	23.6	24.7	24.1
T_6	LM – HG	8.64	8.64	8.64	40.3	43.6	40.4	31.6	35.0	31.8
T_7	FM + RG(4:2)	7.37	7.37	7.37	32.1	33.3	34.7	24.8	25.9	27.3
T_8	LM + RG(4:2)	6.68	6.68	6.68	26.1	26.5	26.5	19.4	19.9	19.8
T_9	FM + BG(4:3)	6.19	6.19	6.19	25.4	26.7	27.4	19.2	20.5	21.2
T_{10}	LM + BG(4:3)	5.50	5.50	5.50	28.7	29.7	29.7	23.2	24.2	24.2
T_{11}	FM + BG(4:3)-HG	11.07	11.07	11.07	35.8	37.2	37.84	24.75	26.18	26.77
T_{12}	LM + BG(4:3)-HG	9.19	9.19	9.19	45.8	46.7	46.66	36.56	37.50	37.47
SEm(±)		0.583	0.583	0.583	2.173	2.273	2.117	1.755	1.870	1.699
CD (P=0.05)		1.190	1.190	1.190	4.437	4.641	4.323	3.584	3.818	3.469

FM: Finger millet, LM: Little millet, RG: Red gram, BG: Black gram, HG: Horse gram

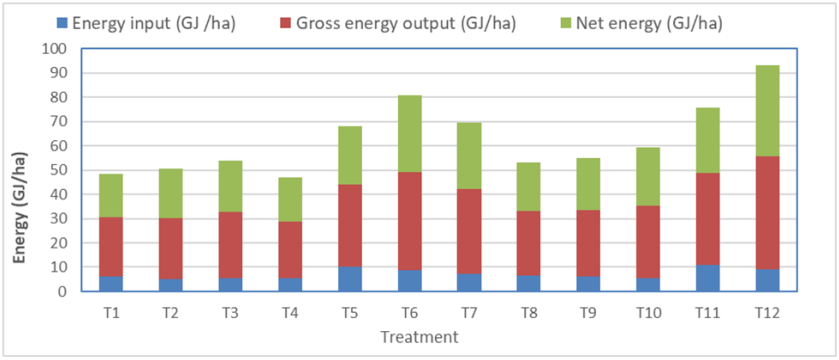

Fig. 2. Energy input, Gross energy output and net energy of millet based cropping system.

CONCLUSIONS

Thus, the study concluded that due to complementary relation of LM and BG intercropping system, when horse gram taken in sequence, resulting in higher yield of the component crops in the system. Inclusion of legumes like black gram as intercrop or horse gram as sequence crop with LM and FM has additive effect overthe yield of base crop as well as succeeding crop. LM + BG - HG system (T_{12}) recorded highest FMEY (3144kg/ha), The total LER was more than one in all the intercropping systems. When the LER is more than one, it indicates the greater biological efficiency of intercropping system. RCC values of all component crops except red gram in little millet+ red gram inter cropping system were greater than one which indicated that all component crops and inter crops gave more yield than

expected except red gram crop in little millet + red gram inter cropping system. LUE was recorded to be highest in red gram based systems (46.58 %) because red gram crop occupied the land for maximum period (170 days). Higher nutrient use efficiency was estimated in LM based system than FM based system due to addition of less nutrient in intercropping system, mutualism and complementary relationships between the intercrops which improve the main crop's yield characteristics with improved space utilisation, effective use of sunlight, nutrient and water. The highest total net energy was estimated in LM + BG - HG (37.4 GJ/ha in T_{12}). These results imply that it was more economically viable to take sequence crop horse gram after little millet and black gram inter cropping in rainfed farming system.

FUTURE SCOPE

Promoting millets as a competitive substitute for other cereal crops is necessary. Future studies should concentrate on increasing millets' yield and profitability by creating better cultivars and agronomic procedures, as well as the application of modern technologies in millet-pulses based cropping system or inter cropping.

REFERENCES

Aasim, M., Umer, E. M. and Karim, A. (2008). Yield and competition indices of intercropping cotton (*Gossypium hirsutum* L.) using different planting patterns. *Tarim Bilimleri Dergisi, 14*(4), 326–333.

Girase, P. P., Sonawane, P. D. and Wadile, S. C. (2007). Effect of pearl millet (*Pennisetum glaucum*) based intercropping system on yield and economics of pearl millet on shallow soils under rainfed conditions. *International Journal of Agricultural Sciences, 3*(2), 192-193.

Kumar, Avanesh and Singh, B. P. (2006). Effect of row ratio and phosphorus level on performance of chickpea (*Cicer arietinum*) - Indian mustard (*Brassica juncea*) intercropping. *Indian Journal of Agronomy, 51*(2), 100–102.

Layek, J., Das, A., Mitran, T., and Nath, C. (2018). Cereal + legume intercropping: an option for improving productivity and sustaining soil health. In : Meena, R.S., Das, A., Yadav, G.S., and Lal, R. (eds), *Legumes for Soil Health and Sustainable Management*. Springer Nature, Singapore, pp.347-386.

Maitra, S., Ghosh, D. C., Sundra. and Jana, P. K. (2001). Performance of intercropping legumes in finger millet at varying fertility levels. *Indian Journal of Agronomy, 46*(1), 38-44.

Nedunchezhiyan, M. (2011). Evaluation of sweet potato (Ipomoea batatas) based strip intercropping systems for yield, competition indices and nutrient uptake. *Indian Journal of Agronomy*, *56*(2), 98-103.

Njoku, S. C, Muoneke, C. O., Okpara, D. A. and Agbo, F. M. O. (2007). Effect of intercropping varieties of sweet potato and okra in an ultisol of southeastern Nigeria. *African Journal of Biotechnology, 6*(14), 1650–1654.

Patil, N. B., Halikatti, S. I., Sajay, Y. H., Kumar, P. B. H., Topagi, S. C. and Pushpa, V. (2010). Influence of intercropping on the growth and yield of little millet and pigeonpea. *International Journal of Agriculture Science, 6* (2), 573-577.

Prakasha, G., Murthy, K. N., Meti, R. N., Jagadish and Prathima, A. S. (2017). Nutrient uptake and economics of finger millet (*Eleusine coracana* L.) under guni method of planting in eastern dry zone of Karnataka. *International Journal of Pure Applied and Biological Sciences, 5*(6), 144-151.

Reddy, T. Y. and Reddy, G. H. S. (2013). Principles of Agronomy. Kalyani Publishers, Ludhiana, pp527.

Shwethanjali, K. V., Kumar, Naik, A. H., Basavaraj Naik, T. and Dinesh Kumar, M. (2018). Effect of Groundnut + Millets Intercropping System on Yield and Economic Advantage in Central Dry Zone of Karnataka under Rainfed Condition. *Int. J. Curr. Microbiol. App. Sci., 7*(9), 2921-2926.

Sharmili, K. and Parasuraman, P. (2018). Effect of little millet based pulses intercropping in rainfed conditions. *International Journal of Chemical Studies, 6*(6), 1073-1075.

Singh, U. K., Bharti, N. and Kumar, V. (2009). System productivity and profitability of pigeonpea based intercropping under rainfed condition. *Journal of Applied Boilogy, 19* (1-2), 23-26.

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