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Finger millet intercropping with legumes step towards increasing farmer's income

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Abstract
A field experiment was conducted during the Kharif season of 2019 at Agronomy Instructional Farm, Mandan Bharti Agriculture College, Saharsa, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, to study the performance of different legumes grown as intercrop with finger millet (*Eleusine coracana* L.) in different row proportions. Seven different intercropping systems along with sole cropping were tested in Randomized Block Design with three replications. Experimental results revealed that almost all the growth characters of finger millet were significantly higher in sole crop in compared to different intercropping systems. Grain and straw yield of finger millet were significantly high (2010 kg/ha) when finger millet was intercropped with black gram at 6:2 pair row ratio among all intercropping system. However, finger millet equivalent yield was significantly high (2258 kg/ha) when finger millet was intercropped with black gram at 4:2 pair row ratio among all intercropping system.

Keywords: Finger millet, legumes, intercropping, yield, harvest index and biological yield

Introduction
Finger millet (*Eleusine coracana* L. Gaertn.), the most important cereal in the dry and rainfed region of world and legumes is the most important crop play a vital role in rained agricultural economy (FAO, 2003) [4]. Millets are important staple food crops to the millions of the people in the arid and semiarid regions of the world due to their greater resistance to pests and diseases, good adaption to a wide range of environment and their good yielding capacity and can withstand significant levels of salinity, short growing season, resistant to water logging, drought tolerant, requires little inputs during growth and with increasing world population and decreasing water supplies, represents important crops for future human use. Among millets, Finger millet known as 'Ragi' or 'chodi' is an important crop in India and is a dry land crop cultivated in both tropical and subtropical regions. Finger millet can be able to survive with 28% of paddy's water needs they are better adapted for current and future droughts. Rurinda *et al.*, (2014) [11] reported that finger millet provides food security to poor people. Growing of only millets is not much remunerative in the present scenario of agriculture to fulfill the diverse demand of consumers and rapidly growing population. Hence, it is an urgent need of inclusion of the legumes in millet based cropping systems. Initial slow growth of finger millet will facilitate the better establishment of intercrops. Moreover, growing of intercrops will suppress the unwanted weed growth and produces greater output from unit area than sole crop. Earlier, the concept of mixed and intercropping was for subsistence farming, but now a days, this concept has been changed into maximization per unit area and time.

The basic concept of intercropping system involves growing together two or more crops with the assumption that two crops can exploit the environment better than one and ultimately produce higher yield since the component crops differ in resources use and when grown together, they complement each other and make overall better use of resources (Yadav *et al.*, 2015) [17]. Intercropping with specific planting geometry and selection of compatible crops is a profitable practice to make use of available light, soil moisture and nutrients more efficiently thus, improving productivity of dryland crops (Kaushik and Gautam, 1987) [5]. The biggest complementary effect and yield advantages occur when the component crops have different growing periods to make their major demand of resources at different time.

Materials and methods

Field experiments were conducted during Kharif 2019 under rained conditions at the Mandan Bharti Agriculture College, Saharsa, Bihar, India. The legume crop of Soybean (JS-9752), Black gram (IPU-2-43) and Groundnut (BG-3) were taken as intercrop in finger millet (GPU-67). The intercrops were sown in finger millet in different row proportions of 4: 2 and 6: 2. The row spacing of finger millet, soybean, black gram and groundnut were maintained at 20 cm,40 cm, 30cm, and 40cm respectively. The legumes crops were sown by dibbling method. The thinning of legume crop was done at 15 days after sowing and only one healthy plant was kept per hill by maintaining the 10 cm spacing between the two plants. The experiment was laid out in randomized block design with three replications. Ten different treatments were studied viz., T1- Sole crop of finger millet, T2- Sole crop of Soybean, T3- Sole crop of Black gram, T4- Sole crop of Groundnut, T5- Finger millet + soybean (4:2), T6- Finger millet + soybean (6:2), T7- Finger millet + Black gram (4:2), T8 -Finger millet + Black gram (6:2), T9- Finger millet + Groundnut (4:2) and T10- Finger millet + Groundnut (6:2). The gross plot size was 23 x 67 m and net plot of 6.0 x 5.40 m. The 5.0 tones of FYM/ ha with recommended dose of fertilizers (60: 40: 25 kg NPK/ ha) was given to the finger millet crop which was applied through urea and single super phosphate. The crops were sown during the first week of June. Necessary plant protection measures were taken to protect the crop from pest and diseases. The inter cultivation two weeding were followed by one hoeing.

Results and discussion

Growth parameters

All the growth parameters of finger millet were significantly high in sole crop compared to intercropping (Table-1). Nigade *et al*. (2012) and Ramamoorthy *et al.* (2004) [9] also reported similar results of low growth characters of finger millet in intercropping. Plant height was affected by intercropping systems and significantly highest plant height (98.200 cm) was produced under finger millet with black gram (6:2) after 120 days after sowing (Table 1). The effect of different treatments on number of total tillers per plant had significant effect. Significantly the higher numbers of total tillers per plant were produced under finger millet with black gram (45.900) at 6:2 row ratios. This might be due to development of better complementary relationship and non-renewable resources like water, nutrients and incoming sunlight. These results are in close conformity with the findings of Rathore and Gautam (2003) [10]. Plant growth is dependent on the rate of accumulation of dry matter. The dry matter accumulation may reflect on the economic yield. Among the intercropping systems, higher total dry matter was recorded in 6:2 row ratio of finger millet with black gram (340.067 kg/ha). It was on par with 4:2 row ratio of Finger millet + Black gram (338.600 kg/ha). Significantly lower total dry matter was recorded in sole crop of Finger millet (295.500) (Kiroriwal and Yadav, 2013) [6]. High dry matter under intercropping may be due to the weed suppressing capability of intercropping over monocropping (Yih, 1982) [18].

Grain and straw yield

The **s**ole crop of finger millet recorded the highest grain and straw yield (2017 kg/ha and 4830 kg/ha respectively) which was significantly superior over rest of the treatments. Amongst the intercrop treatments, the maximum yield of finger millet (2010 kg/ha) was recorded in the treatment of finger millet + black gram (6:2) followed by (1975 kg/ha) in finger millet + black gram (4:2). Grain and straw yield of finger millet were reduced considerably when inter cropped with legumes compared with the pure stand of finger millet during the year as reported by Singh and Arya (1999) [14] and Mitra *et al.* (2001) [8] (Table 2). Such reduction was due to decrease in plant stand compared to that of sole cropping of finger millet. Siddeswaran *et al.*, 1989 [13] also noticed reduction in grain and straw yields of finger millet under intercropping situation. It was further noticed that sole Soybean recorded the maximum grain and was superior to other intercropping systems. T5– Finger millet + soybean (4:2) combination recorded the second highest productivity in terms of Grain yield of inter crops which were also greater than those of other intercropping systems during the years. However, T10- Finger millet + Groundnut (6:2) combination recorded the lowest productivity in terms of Grain of inter crops.

Grain equivalent yield of finger millet

As regards the finger millet grain equivalent yield significantly highest yield, (2258 kg/ha) was observed by the treatment T7 where Black gram was taken as intercrop in finger millet in 4:2 row proportion. But it was at par with the treatment T8 where Black gram was taken as an intercrop in finger millet in 6:2 row proportions (2218 kg/ha). Similar results were also reported by Thorat *et al*. (1986) [16], Mahadkar and Khanvilkar (1988) [7], Shankarlingappa and Hegade (1992) [12] and Ramamoorthy *et al*. (2004) [9]. It indicates that it is beneficial to raise the finger millet with intercrops rather than sole crop alone.

Harvest index and Biological yield

A critical analysis of data clearly indicates that there was significant variation in harvest index due to different treatments. The data revealed that the maximum harvest index (HI) was observed (338%) in Finger millet + Black gram (4:2) which was at par with Finger millet+ Black gram (6:2). Minimum harvest index (339%) was recorded under sole crop of finger millet (T1) treatment. This reduction in harvest index of finger millet is attributed by Bhowmik *et al*., 2012 [2]. Among various intercropping systems, biological yield was the highest with 6:2 row ratio in Finger millet + Black gram (6834 kg/ha) and 4:2 row ratio in Finger millet + Black gram (6676 kg/ha). Corresponding decrease in biological yield of finger millet at 4:2 row ratio. This reduction in biological yield of finger millet is attributed to decrease in proportionate area of finger millet in intercropping (Chandra *et al.*, 2009a) [3].

Table 1: Growth parameters of finger millet at different stages as influenced by different treatments

Treatments	Plant height (cm)				No of tillers				Dry matter (kg/ha)			
	30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS
T1- Finger millet (Sole)	18.200	67.200	92.900	98.400	24.900	49.867	47.900	46.000	22.100	176.100	280.200	341.633
T2- Soybean (Sole)												
T3- Black gram (Sole)												

T4- Groundnut (Sole)												
T5- Finger millet + Soybean (4:2)	17.800	65.200	91.200	96.600	23.500	48.100	46.300	43.200	20.400	167.467	272.200	333.700
T6- Finger millet + Soybean (6:2)	18.000	65.600	91.500	97.000	23.800	48.500	46.700	43.833	20.733	169.333	273.300	335.367
T7- Finger millet + Black gram (4:2)	18.400	66.900	92.300	97.900	24.500	49.400	47.200	45.700	21.667	175.000	276.200	338.600
T8- Finger millet + Black gram (6:2)	18.600	67.100	92.700	98.200	24.700	49.700	47.600	45.900	21.967	175.400	277.500	340.067
T9- Finger millet + Groundnut (4:2)	18.200	66.300	91.500	97.500	24.000	48.900	46.800	45.100	20.367	173.500	274.300	336.133
T10- Finger millet + Groundnut (6:2)	18.400	66.700	91.800	97.800	24.300	49.100	47.000	45.400	21.600	173.800	275.500	337.533
SEM	0.233	0.249	0.120	0.086	0.088	0.227	0.060	0.086	0.261	0.158	0.493	0.344
CD at 5%	N/A	0.776	0.373	0.267	0.274	0.707	0.186	0.267	0.813	0.493	1.534	1.072

Table 2: Grain and Straw yield, Grain/haulm/pod yield of inter crops, Finger millet equivalent yield, Biological yield and Harvest Index of Finger millet as influence by different treatments

Treatments	Grain yield of Finger millet (Kg/ha)	Grain/haulm/pod yield of inter crops (Kg/ha)	Finger millet equivalent yield (Kg/ha)	Straw yield of Finger millet (Kg/ha)	Biological yield (kg/ha)	Harvest Index (%)
T1- Finger millet (Sole)	2017			4830	6847	339
T2- Soybean (Sole)		1565	1843		4147	264
T3- Black gram (Sole)		1285	2325		3020	235
T4- Groundnut (Sole)		1425	2302		4660	327
T5- Finger millet + Soybean (4:2)	1831	1435	1690	4248	6079	332
T6- Finger millet + Soybean (6:2)	1865	1325	1560	4290	6155	330
T7- Finger millet + Black gram (4:2)	1975	1248	2258	4701	6676	338
T8- Finger millet + Black gram (6:2)	2010	1226	2218	4824	6834	340
T9- Finger millet + Groundnut (4:2)	1905	1305	2108	4382	6287	330
T10- Finger millet + Groundnut (6:2)	1933	1275	2060	4465	6398	330
SEM	5.893	2.981		3.936		
CD at 5%	18.360	9.013		12.262		

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