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# Performance of intercropping of legumes with finger millet (*Eleusine coracana*) for enhancing productivity, sustainability and economics in Koshi region of Bihar

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**Abstract**
A field experiment on diversification of finger millet (*Eleusine coracana* L. Gaertn.) through black gram (*Phaseolus mungo* L.), soybean (*Glycine max*) and groundnut (*Arachis hypogea*) intercropping was carried out at Agronomy Instructional Farm, Mandan Bharti Agriculture College, Saharsa, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India to identify the most promising intercropping systems for improving and stabilizing productivity. Based on the results, it was observed that intercropping of finger millet with black gram, groundnut and soybean recorded significantly higher finger millet equivalent yield (4233, 4013 and 3521 kg/ha) at 4:2 ratio than sole finger millet (2017 kg/ha) however, grain and straw yield of finger millet were recorded superior in 6:2 ratio of almost all inter cropping systems. Almost all growth as well as yield attributing characters of finger millet were recorded significantly higher in finger millet sole however among inter cropping system finger millet intercropped with Black gram followed by groundnut and soybean. Among the ratio of intercropping system, all inter cropping systems with 4:2 row ratio were recorded higher finger millet equivalent yield along with net income than 6:2 row ratio.

**Keywords:** Finger millet, productivity, sustainability, economics, intercropping

## Introduction
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 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) [10] 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 fulfil 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. Midega *et al*., (2010) [5] reported that intercropping of finger millet effectively suppress the disease of the crop. Finger millet also has wonderful health benefits as it increases bone strength, regulating blood sugar levels, protecting from risk of stroke by regulating cholesterol, helps in treating anaemia, increases lactation and also has anti aging properties. Intercropping is an ancient method of intensive agriculture that involves cultivation of two or more crops simultaneously on the same piece of land. Intercropping has been practiced in many parts of the world as a way to maximize land productivity in a natural and sustainable way. The idea behind the technique is that crops differ in their growth requirements and are complementary to each other and make a better overall use of available resources. Moreover, it is the most common practice used in sustainable agricultural systems which have an important role in increasing the productivity and stability of yield in order to improve resource utilization and environmental factors (Alizadeh *et al*., 2010) [1].

## Materials and Methods

Field experiments were conducted during Kharif 2019 under rained conditions at 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 tonnes 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 higher in sole crop compared to all intercropping system (Table-1). Nigade *et al*. (2012) [12] and Ramamoorthy *et al.* (2004) [8] also reported similar results of low growth characters of finger millet in intercropping. Among intercropping system, significantly highest plant height (98.2 cm) was produced under finger millet with black gram (6:2) at 120 DAS (Table 1). The effect of different treatments on number of total tillers per running meter had significant effect. Total tillers per running meter were significantly higher under finger millet with black gram (45.90) in 6:2 row ratios at 120 DAS among intercropping system. Better environment particularly the light interception by outer rows of finger millet in this row ratio lead to higher tillers per running meter in these treatments or 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 Narasimha Rao *et al*. (1963) [7], Kalaraju (2009) [20] and Rajesh (2011) [11]. These results are also in close conformity with the findings of Rathore and Gautam (2003). 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 (340.0 kg/ha) which was at par with 4:2 row ratio of Finger millet + Black gram (338.6 kg/ha). High dry matter under intercropping may be due to fix atmospheric N and supply it to the associated FM as well as weed suppressing capability of intercropping over mono cropping (Yih, 1982) [11].

### Yield attributing characters

Table 2 shows that almost all yield attributing characters of finger millet were significantly high in sole crop. Among different intercropping systems, Finger millet + Black gram (6:2) row ratio were produced higher number (8.3) and length (5.4cm) of finger in finger millet. Improvement in yield attributes of FM when intercropped with BG could be ascribed to the ability of black gram to fix atmospheric N and supply it to the associated FM, better moisture conservation, suppression of weeds and higher sunshine availability to relatively taller plants of finger millet. Joshi and Mehra, 1989 [19] reported similar results. The maximum number of grains/ear (2395) and test weight (3.6 gm) were observed in T8- Finger millet + Black gram (6:2) which were at par with T7 -Finger millet + Black gram (4:2). The minimum number grains/ear (2,117) and test weight (2.4 gm) were recorded under T5- Finger millet + soybean (4:2) among inter cropping system. This was in accordance with earlier finding of Rajesh (2011) [11] in finger millet.

### 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 finger millet + groundnut and finger millet + soybean. Grain and straw yield of finger millet were reduced considerably when inter cropped with legumes compared with the pure stand of finger millet as reported by Singh and Arya (1999) [15] and Mitra *et al*. (2001) [6]. Such reduction was due to decrease in plant stand compared to that of sole cropping of finger millet. Siddeswaran *et al.*, 1989 [14] also noticed reduction in grain and straw yields of finger millet under intercropping situation. Among all the intercropping system, finger millet intercropped with black gram in row ratio of 6:2 recorded significantly higher grain and straw yield than 4:2 ratio of intercropping systems.

As regards the finger millet grain equivalent yield, significantly highest yield (4233 kg/ha) was observed by the treatment T7 where black gram was taken as intercrop in finger millet in 4:2 row proportion followed by at the same ratio of groundnut and soybean. Similar results were also reported by Thorat *et al.* (1986) [16], Mahadkar and Khanvilkar (1988) [4], Shankarlingappa and Hegade (1992) [13] and Ramamoorthy *et al.* (2004) [8]. It indicates that it is beneficial to raise the finger millet with intercrops rather than sole crop alone.

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 (340%) in Finger millet + Black gram (6:2) which was followed by Finger millet+ Black gram (4:2). Minimum harvest index (235%) was recorded under sole crop of Black gram (T3) 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 was recorded in 4:2 row ratio among all inter cropping systems. 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].

**Economics**

The results clearly showed that sole groundnut recorded the highest net return than all other sole crops (Table 4). This was mainly due to high price of groundnut. However, the highest benefit/cost ratio was obtained from sole black gram due to higher equivalent yield of finger millet. The lowest net return and benefit/cost ratio was obtained from sole finger millet, which might be due to low productivity per unit area.

Looking to overall economics all intercropping of finger millet with different legumes intercropping gave significantly higher net realization over that of sole finger millet. This could be attributed to higher yield advantage under sole legumes and intercropping systems. Finger millet + Black gram (4:2) combination recorded the highest net return of Rs. 68776/ha and benefit cost ratio of 2.82 followed by finger millet + Black gram (6:2) which gave net return of Rs. 68316/ha with 2.76 benefit cost ratio which confirmed the superiority of Finger millet with black gram at 4:2 pair row ratio over other treatments. Similar results were also reported by Yadav and Jat (2005) [17].

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

| Treatments | Plant height (cm) | | | | No of tillers | | | | Dry matter per running meter (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) | 17.8 | 65.2 | 91.2 | 96.6 | 23.5 | 48.1 | 46.3 | 43.2 | 20.4 | 167.4 | 272.2 | 333.7 |
| T6- Finger millet + soybean (6:2) | 18.0 | 65.6 | 91.5 | 97.0 | 23.8 | 48.5 | 46.7 | 43.8 | 20.7 | 169.3 | 273.3 | 335.3 |
| T7- Finger millet + Black gram (4:2) | 18.4 | 66.9 | 92.3 | 97.9 | 24.5 | 49.4 | 47.2 | 45.7 | 21.6 | 175.0 | 276.2 | 338.6 |
| T8- Finger millet + Black gram (6:2) | 18.6 | 67.1 | 92.7 | 98.2 | 24.7 | 49.7 | 47.6 | 45.9 | 21.9 | 175.4 | 277.5 | 340.0 |
| T9- Finger millet + Groundnut (4:2) | 18.2 | 66.3 | 91.5 | 97.5 | 24.0 | 48.9 | 46.8 | 45.1 | 20.3 | 173.5 | 274.3 | 336.1 |
| T10- Finger millet + Groundnut (6:2) | 18.4 | 66.7 | 91.8 | 97.8 | 24.3 | 49.1 | 47.0 | 45.4 | 21.6 | 173.8 | 275.5 | 337.5 |
| 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:** Yield attributing characters of finger millet as influenced by different treatments

| Treatments | No. of ears/m$^2$ | Length of Earhead (cm) | Wt. of earhead (gm) | No. of fingers /ear | Length of fingers /ear(cm) | No. of grains /ear | Test wt. (gm) |
|---|---|---|---|---|---|---|---|
| T1- Finger millet (Sole) | 111 | 11.0 | 35.100 | 8.100 | 5.600 | 2401 | 3.8 |
| T2- Soybean (Sole) | | | | | | | |
| T3- Black gram (Sole) | | | | | | | |
| T4- Groundnut (Sole) | | | | | | | |
| T5- Finger millet + soybean (4:2) | 92 | 8.5 | 32.4 | 7.0 | 4.6 | 2117 | 2.4 |
| T6- Finger millet + soybean (6:2) | 95 | 8.8 | 32.7 | 7.2 | 4.7 | 2149 | 2.6 |
| T7- Finger millet + Black gram (4:2) | 105 | 9.6 | 34.3 | 7.9 | 5.2 | 2300 | 3.2 |
| T8- Finger millet + Black gram (6:2) | 110 | 9.8 | 34.8 | 8.3 | 5.4 | 2395 | 3.6 |
| T9- Finger millet + Groundnut (4:2) | 97 | 9.2 | 33.1 | 7.4 | 4.8 | 2232 | 2.8 |
| T10- Finger millet + Groundnut (6:2) | 103 | 9.4 | 33.5 | 7.6 | 5.1 | 2265 | 3.0 |
| SEM | 0.208 | 0.139 | 0.095 | 0.074 | 0.100 | 12.059 | 0.132 |
| CD at 5% | 0.649 | 0.432 | 0.297 | 0.231 | 0.312 | 37.570 | 0.410 |

**Table 3:** Yield of Finger millet and different intercrops as influence by different treatment

| Treatments | Grain yield of Finger millet (kg/ha) | Straw yield of Finger millet (kg/ha) | Grain/haulm/pod yield of inter crops (kg/ha) | Finger millet equivalent yield (kg/ha) | Biological yield (kg/ha) | Harvest Index (%) |
|---|---|---|---|---|---|---|
| T1- Finger millet (Sole) | 2017 | 4830 | | 2017 | 6847 | 339 |
| T2- Soybean (Sole) | | | 1565 | 1843 | 4147 | 264 |
| T3- Black gram (Sole) | | | 1285 | 2325 | 3020 | 235 |
| T4- Groundnut (Sole) | | | 1425 | 2303 | 4660 | 327 |
| T5- Finger millet + soybean (4:2) | 1831 | 4248 | 1435 | 3521 | 6079 | 332 |
| T6- Finger millet + soybean (6:2) | 1865 | 4290 | 1325 | 3426 | 6155 | 330 |
| T7- Finger millet + Black gram (4:2) | 1975 | 4701 | 1248 | 4233 | 6676 | 338 |
| T8- Finger millet + Black gram (6:2) | 2010 | 4824 | 1226 | 4228 | 6834 | 340 |
| T9- Finger millet + Groundnut (4:2) | 1905 | 4382 | 1305 | 4014 | 6287 | 330 |
| T10- Finger millet + Groundnut (6:2) | 1933 | 4465 | 1275 | 3993 | 6398 | 330 |
| SEM | 5.893 | 3.936 | 2.981 | | | |
| CD at 5% | 18.360 | 12.262 | 9.013 | | | |

**Table 4:** Economics of finger millet as influenced by different treatments

| Treatments | Grain yield (kg/ha) | Finger millet equivalent yield (kg/ha) | Cost of cultivation (Rs/ha) | Gross return (Rs/ha) | Net return (Rs/ha) | B:C ratio |
|---|---|---|---|---|---|---|
| T1- Finger millet (Sole) | 2017 | 2017 | 17500 | 44374 | 26874 | 1.53 |
| T2- Soybean (Sole) | | 1843 | 24700 | 68191 | 43491 | 1.76 |
| T3- Black gram (Sole) | | 2325 | 20400 | 69750 | 49350 | 2.41 |
| T4- Groundnut (Sole) | | 2302 | 30850 | 92080 | 61230 | 1.98 |
| T5- Finger millet + soybean (4:2) | 1831 | 3521 | 24850 | 77462 | 52612 | 2.11 |
| T6- Finger millet + soybean (6:2) | 1865 | 3425 | 25300 | 75350 | 50050 | 1.97 |
| T7- Finger millet + Black gram (4:2) | 1975 | 4233 | 24350 | 93126 | 68776 | 2.82 |
| T8- Finger millet + Black gram (6:2) | 2010 | 4228 | 24700 | 93016 | 68316 | 2.76 |
| T9- Finger millet + Groundnut (4:2) | 1905 | 4013 | 26450 | 88286 | 61836 | 2.33 |
| T10- Finger millet + Groundnut (6:2) | 1933 | 3993 | 26800 | 87846 | 61046 | 2.27 |
| SEM ± | 5.893 | | | | | |
| CD at 5% | 18.360 | | | | | |

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