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 rainfed 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, 30 cm, and 40 cm 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 (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 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.

Grain and straw yield
The sole crop of finger millet recorded the highest grain and straw yield (2019 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 Thirumalai and Prutham (2012) [15] and Tirtha et al. (2009a) [14]. 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. 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 to Bhownik 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].

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) (Kioriwal and Yadav, 2013) [6]. High dry matter under intercropping may be due to the weed suppressing capability of intercropping over monocropping (Yih, 1982) [13].

![Table 1: Growth parameters of finger millet at different stages as influenced by different treatments](http://www.chemijournal.com)

| 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 | 230.200 | 341.633 |
| T2- Soybean (Sole)     |           |           |           |         |       |       |       |       |       |         |         |         |
| T3- Black gram (Sole)  |           |           |           |         |       |       |       |       |       |         |         |         |

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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                                      |                                            |                                       | 6830                                | 3687                    | 339              |
| T2- Soybean (Sole)                 | 1565                                     | 1843                                       |                                       | 4248                                | 6079                    | 332              |
| T3- Black gram (Sole)              | 1285                                     | 2325                                       |                                       | 5020                                | 6155                    | 330              |
| T4- Groundnut (Sole)               | 1425                                     | 2302                                       |                                       | 4660                                | 6834                    | 340              |
| 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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