Evaluation of Sesame (*Sesamum indicum* L.) Based Intercropping Systems with Millets by Varying Row Proportions under Dry Condition

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**A BSTRACT**

**Background:** With the constant rise of the world population, global food security is progressively under threat. So, there is a need for an effective crop scheme such as intercropping that checks all drawbacks and meets the world’s current and future food needs. Sesame (*Sesamum indicum* L.) is one of the most important minor oilseed crops of Karnataka and cultivated under rainfed situation. Under dry condition, instead of depending on mono-cropping, intercropping is always a better option. As millets are short duration crops, to make better utilization of resources and space; millets are well suited for intercropping systems. Keeping this in view the research study was carried out.

**Methods:** A field experiment was conducted during kharif season of 2018-19 at the KVK farm College of Agriculture, Vijayapur in shallow medium black soils. The experiment was laid out in Randomized complete block design with 13 treatments viz. sesame intercropped with foxtail millet, little millet and proso millet in 1:2, 2:4, 3:3 row proportion and their respective sole crops.

**Result:** Sole sesame recorded significantly higher grain yield (586 kg ha\(^{-1}\)) than the other intercropped sesame. Among intercrops sole foxtail millet recorded higher grain yield (1,435 kg ha\(^{-1}\)). Significantly higher (703 kg ha\(^{-1}\)) sesame equivalent yield (SEY) was recorded in sesame+foxtail millet in 2:4 row proportions and was on par with sesame + little millet (667 kg ha\(^{-1}\)) in 2:4 row proportions. While lowest SEY was observed in sesame + little millet in 3:3 row proportions (631 kg ha\(^{-1}\)). Significantly higher land equivalent ratio (LER) and area time equivalent ratio (ATER) were recorded in sesame + foxtail millet in 2:4 row proportions (1.33 and 1.28, respectively). Higher dry matter accumulation was noticed in sole sesame (9.70 g plant\(^{-1}\)) compared to other intercropped sesame. Significantly higher gross returns (` 50,228 ha\(^{-1}\)), net returns (` 36,875 ha\(^{-1}\)) and B: C (3.76) was recorded in sesame + foxtail millet in 2:4 row proportions and this intercropping system is more remunerative over sole crops.

**Key words:** B:C., Millets, Row proportion, Sesame, Sesame equivalent yield, Yield.

**INTRODUCTION**

With the constant rise of the world population, global food security is progressively under threat. The present food production does not meet this requirement. Despite elevated demand for food, global warming has further deepened fear of low manufacturing. Tropical regions of the world will be more severely affected by these circumstances (Anonymous, 2018). Therefore, eco-friendly quantitative and qualitative food manufacturing technologies need to be developed that will support future world food security in terms of both amount and nutrition. In addition, for worldwide food security, adequate exploitation of manufacturing systems requires to be resolved. Now, there is a need for an effective crop scheme such as intercropping that checks all drawbacks and meets the world’s current and future food needs.

Sesame (*Sesamum indicum* L.) is one of the most important minor oilseed crops belonging to family pedaliaceae. Sesame is also known as til (Hindi, Punjabi, Assamese, Bengali and Marathi). India has a world’s largest coverage area (24 %) followed by Mynamar, Sudan, China and Uganda, but higher productivity is in China (Anonymous, 2016). Sesame comes up well in tropical and sub-tropical regions of the world. In India, it is grown over an area of 17.5 lakh hectares with production of 7.70 lakh tonnes at productivity of 441 kg/ha. In Karnataka, the major area of sesame is under rainfed situation. It is cultivated over an area of 0.35 lakh ha with production of 0.22 lakh tonnes per year and productivity of 629 kg/ha (Anonymous, 2017a).

In India, the major area of sesame is in the states of Maharastra, Rajasthan, Orissa, Andhra Pradesh, Tamil Nadu, West Bengal, Gujarth and Karnataka. In Karnataka, among sesame growing districts, Gulbarga stands first in area followed by Koppal, Mysore and Bidar. However, the productivity is higher in Chitradurga and Chkmagalur districts. Millets are known as famine reserves as they can come up well in low moisture conditions. In general, millets provide...
many essential micronutrients and vitamins that can boost nutrition for human health. Under dry condition, instead of depending on mono-cropping, intercropping is always a better option. As millets are short duration crops, to make better utilization of resources and space; millets are well suited for intercropping systems.

**MATERIALS AND METHODS**

A field experiment was conducted to assess the performance of sesame (*Sesamum indicum* L.) based intercropping systems with millets at different row proportions during kharif season of 2018-19 under dry condition at Krishi Vigyana Kendra, Vijayapur, Karnataka on shallow medium black soil having pH 8.14 and EC 0.54 dS m⁻¹. The soil was medium in organic carbon content (0.51 %) and available P₂O₅ (31 kg ha⁻¹) and low in available N (210 kg ha⁻¹) with available K content (268 kg ha⁻¹) and clay content (60.05 %). The experimental site comes under the Northern Dry Zone of Karnataka (Zone 3).

There were thirteen treatments as detailed in Table 1 i.e., intercropping of sesame with foxtail millet, little millet and proso millet in 1:2, 2:4 and 3:3 proportion and four sole crops viz., sesame (DS-5), foxtail millet (DHFT-109-3), little millet (DHLM-36-3) and proso millet (DHP-2769). The duration of sesame and millets i.e. foxtail millet, little millet and proso millet were 90, and 75 days, respectively. The spacing followed was 30x15 cm for sesame and 30x5 cm for minor millets. The experiment was laid out in randomized complete block design with three replications in plot size of 5.4 m x 4.5 m.

Both the component crops were planted simultaneously and fertilizers were applied to all crops as per the recommended package of the region. In intercropping system, the component crops received fertilizers in proportionate to their plant density at the time of sowing in the form of urea, DAP and muriate of potash. The crops were sown as per the row proportions in intercropping systems and as well as their soles during the period of first fortnight of July (FN) i.e., on 17th July 2018, when field was an attained optimum moisture condition. The total rainfall received during cropping season was 466.3 mm i.e., in July, August, September, October, November, and December 23.40, 53.60, 91.90, 5.0, 32.8, 0.0 mm, respectively.

The growth and yield observations were recorded from the net plots and grain yield of various crops were converted to hectare basis in kilograms. The economics of each system was computed with prevailing market prices of that year. The yield was further computed for sesame equivalent yield (SEY), land equivalent ratio (LER), gross and net returns as well as BC ratio to assess the system productivity. Calculated by using following formula:

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SEY = \frac{\text{Price of millets (kg ha}^{-1})}{\text{Price of sesame (kg ha}^{-1})} \times \frac{\text{Yield of sesamem}}{\text{Yield of sesame}}
\]

\[
LER = \frac{\text{Yield of sole sesame}}{\text{Yield of sesamem in intercropping system}} + \frac{\text{Yield of millets in intercropping systems}}{\text{Yield of sole millets}}
\]

**RESULTS AND DISCUSSION**

**Effect of intercropping on yield and intercropping indices**

The data presented in (Table 1) reveals that, among the various intercropping systems tried with sesame, sesame + foxtail millet (3:3) intercropping system recorded higher seed yield of sesame (255 kg ha⁻¹). Increase in seed and stalk yield is mainly due to contribution of yield attributes viz., number of capsules per plant (23.93), seed yield per plant

**Table 1: Sesame equivalent yield (SEY), land equivalent ratio (LER), area time equivalent ratio (ATER) as influenced by different intercropping system.**

| Treatment                              | Treatment          | Seed yield (kg ha⁻¹) | SEY | LER | ATER |
|----------------------------------------|--------------------|----------------------|-----|-----|------|
| T₁ - Sesame + Proso millet (1:2)       |                    | 214                  | 1225| 645 | 1.23 | 1.19 |
| T₂ - Sesame + Foxtail millet (2:4)     |                    | 233                  | 1337| 703 | 1.33 | 1.28 |
| T₃ - Sesame + Foxtail millet (3:3)     |                    | 255                  | 1143| 658 | 1.23 | 1.19 |
| T₄ - Sesame + Little millet (1:2)      |                    | 221                  | 1247| 640 | 1.26 | 1.21 |
| T₅ - Sesame + Little millet (2:4)      |                    | 230                  | 1300| 667 | 1.31 | 1.26 |
| T₆ - Sesame + Little millet (3:3)      |                    | 251                  | 1131| 631 | 1.23 | 1.19 |
| T₇ - Sesame + Proso millet (1:2)       |                    | 233                  | 1214| 634 | 1.26 | 1.03 |
| T₈ - Sesame + Proso millet (2:4)       |                    | 226                  | 1240| 649 | 1.27 | 1.04 |
| T₉ - Sesame + Proso millet (3:3)       |                    | 249                  | 1145| 634 | 1.24 | 1.02 |
| T₁₀ - Sesame Sole                      |                    | 586                  | -   | 586 | 1.00 | 1.00 |
| T₁₁ - Foxtail millet Sole             |                    | -                    | 1435| 505 | 1.00 | 0.95 |
| T₁₂ - Little millet Sole              |                    | -                    | 1414| 498 | 1.00 | 0.95 |
| T₁₃ - Proso millet Sole               |                    | -                    | 1409| 473 | 1.00 | 0.74 |

S.E.m. ± 12.3                          | 12.3               | 51.39                | 18.82| 0.03 | 0.03 |

CD=0.5% 36.4                           | 36.4               | 150.73               | 54.94| 0.11 | 0.09 |
(2.51 g) and 1000-seed weight of sesame (3.46 g). The higher sesame yield in sesame + foxtail millet (3:3) was due to the higher population of sesame in respective intercropping system compared to other intercropping system and contribution of both growth and yield parameters are also accountable in this regard. The higher grain yield of millets was recorded with foxtail millet (1337 kg ha\(^{-1}\)) grown in sesame + foxtail millet (2:4) intercropping system compared to other intercropping system due to the improved yield attributes viz., panicle length (14.67), number of productive tillers per meter row length (73.83), yield per meter row length (105.30 g) and 1000-seed weight of foxtail millet (3.47 g) compared to other intercropping system. Higher grain yield of millets in 2:4 row ratios might be due to the least competition among the intercrop for different growth and other resources.

The highest sesame equivalent yield was recorded with sesame + foxtail millet of 2:4 (703 kg ha\(^{-1}\)) and it was on par with sesame + foxtail millet of 3:3 (658 kg ha\(^{-1}\)), sesame + little millet (2:4) (667 kg ha\(^{-1}\)), sesame + proso millet of 2:4 (649 kg ha\(^{-1}\)). The Higher sesame equivalent yield in sesame + foxtail millet (2:4) was due to higher contribution by sesame and millets and their market price coupled with better utilization of resources by component crops in the intercropping system also the higher light transmission values in respective treatment (43.30 %) leads to higher accumulation of photosynthates, which in turn increases the yield of the system. The results are in conformity with the findings of Basavarajappa (2003) who reported that highest foxtail millet equivalent yield was recorded when foxtail millet was grown with pigeonpea where 100 per cent pigeonpea populations were maintained. Similarly, Dinesh Kumar et al. (2017) reported that among all intercropping system sesame grown with green gram in 3:2 paired row system recorded the highest (944 kg ha\(^{-1}\)) sesame equivalent yield, which was statistically at par with sesame with green gram in 2:1 paired row systems.

The Land equivalent ratio indicates the clear picture of merits and demerits of intercropping system. In present study, intercropping of sesame + foxtail millet in 2:4 ratio recorded significantly higher LER (1.33) compared to sole crops and it was on par with all other intercropping system. This might be due to the fact that component crops were differed in utilizing growth and other resources and converting them into sink more efficiently resulting in higher yield per unit area compared to sole crop. Numerically higher LER values of 2:4 row proportions exceeded 3:3 row proportions. These results are in conformity with Abdel and Rea (2014) who reported that increase in millets population did not exert heavy competition between the component crops in groundnut + sesame intercropping system. Similarly, in castor based millet intercropping by Prajwal and Kalaghatagi (2018) who reported that higher land equivalent ratio (LER) was found in castor + little millet (1.58).

The area time equivalent ratio (ATER) revealed that efficient intercropping systems by showing differences among different associations. The higher mean values of ATER was recorded by the sesame + foxtail millet in 2:4 row proportion (1.28) intercropping system. It was due to higher intercrop yield and a lower reduction in base crop yield. The lowest ATER was recorded from by the sesame + proso millet (1.02). Shivaraj (2015) reported that higher area time equivalent ratio (ATER) (1.17) in 4:2 row ratio of groundnut + little millet intercropping systems. Vajjaramatti and Kalaghatagi (2016) reported significantly higher area time equivalent ratio (ATER) in pigeon pea + little millet (1.64) in 1:2 row ratio compared to sole crops. Thus, the higher ATER when associated crops are short duration leading to higher equivalent yield per unit growing period.

**Effect of intercropping on economics**

The data presented in (Table 2) reveals that among the intercropping systems, significantly higher gross and net returns were recorded in 2:4 sesame + foxtail millet (\(\times 50,228\))

| Treatment | Cost of cultivation (\(\text{` ha}\^{-1}\)) | Gross returns (\(\text{` ha}\^{-1}\)) | Net returns (\(\text{` ha}\^{-1}\)) | BC ratio |
|-----------|------------------------------------------|----------------------------------|-------------------------------|----------|
| \(T_1\)  | INITIAL - Sesame + Foxtail millet (1:2)  | 13353                            | 45890                         | 32537    | 3.44     |
| \(T_2\)  | Sesame + Foxtail millet (2:4)            | 13353                            | 50228                         | 36875    | 3.76     |
| \(T_3\)  | Sesame + Foxtail millet (3:3)            | 13749                            | 47035                         | 33286    | 3.44     |
| \(T_4\)  | Sesame + Little millet (1:2)             | 13476                            | 46950                         | 33114    | 3.46     |
| \(T_5\)  | Sesame + Little millet (2:4)             | 13476                            | 48693                         | 35217    | 3.61     |
| \(T_6\)  | Sesame + Little millet (3:3)             | 13857                            | 46213                         | 32356    | 3.35     |
| \(T_7\)  | Sesame + Proso millet (1:2)              | 13405                            | 45235                         | 31830    | 3.37     |
| \(T_8\)  | Sesame + Proso millet (2:4)              | 13405                            | 45719                         | 32314    | 3.41     |
| \(T_9\)  | Sesame + Proso millet (3:3)              | 14134                            | 45308                         | 31174    | 3.21     |
| \(T_{10}\) | Sesame Sole                             | 12890                            | 38336                         | 25446    | 3.02     |
| \(T_{11}\) | Foxtail millet Sole                     | 12373                            | 37042                         | 24669    | 2.99     |
| \(T_{12}\) | Little millet Sole                      | 12588                            | 36053                         | 23465    | 2.86     |
| \(T_{13}\) | Proso millet Sole                       | 12862                            | 34448                         | 21586    | 2.68     |
| \(S.E.m. \pm\) |                         | -                               | 1224.88                       | 1224.88  | 0.09     |
| **CD=0.5\%** |                                 | -                               | 3575.12                       | 3575.12  | 0.26     |
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The lowest gross return was recorded in sesame + proso millet of 1:2 (34,235 ha\(^{-1}\)) and lowest net returns was recorded in sesame + proso millet of 3:3 (31,174 ha\(^{-1}\)). The higher gross and net returns in intercropping systems were mainly due to higher sesame and millet yields and higher market price of sesame. The benefit cost ratio also followed similar trend, which was significantly higher in 2:4 row ratio of sesame + foxtail millet (3.76) and it was on par with 2:4 row ratio of sesame + little millet (3.67). This might be due to the higher market price of sesame and lower cost of cultivation in these treatments. The results are in line with the findings of Sunilkumar et al. (2013), reported that significantly higher gross return (34,160 ha\(^{-1}\)), net return (27,336 ha\(^{-1}\)) and BC ratio (4.02) was obtained in pearl millet (multicut) + cowpea intercropping systems.

**CONCLUSION**

Significantly higher sesame equivalent yield, land equivalent ratio and benefit cost ratio was obtained with intercropping system compared to their sole cropping. The data revealed that, growing of sesame with foxtail millet at 2:4 row proportion recorded higher sesame equivalent yield (703 kg ha\(^{-1}\)) as compared to other intercropping system and also recorded higher land equivalent ratio (1.33). Sesame + foxtail millet intercropping system is more remunerative over sole cropping. Therefore, it is concluded that sesame + foxtail millet (2:4) intercropping system was found suitable for northern dry zone of Karnataka under rainfed condition.

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