# Evaluating little millet (*Panicum sumatrense* L.) based intercropping system on growth, yield and nutrient status of soil under rainfed condition


## ABSTRACT

**Aims:** To determine the suitable component crop and its row pattern for enhancing growth and yield of little millet under intercropping system.
**Study design:**Randomized complete Block Design (RBD).
**Place and Duration of Study:**The field experiment was carried out during the *rabi* season from October 2023 – January 2024 at Instructional north farm in Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu.
**Methodology:**This field experiment consists of 3 replications with eleven treatments *viz*., $T_1$ – Little millet sole crop, $T_2$ – Little millet + black gram (4:1), $T_3$ – Little millet + black gram (6:1), $T_4$ – Little millet + green gram (4:1), $T_5$ – Little millet + green gram (6:1), $T_6$ – Little millet + redgram (4:1), $T_7$ – Little millet + redgram (6:1), $T_8$ – Little millet + cowpea (4:1), $T_9$ – Little millet + cowpea (6:1), $T_{10}$ – Little millet + bengal gram (4:1), $T_{11}$ – Little millet + bengal gram (6:1).
**Results:**The results of the experiment showed that$T_2$little millet + black gram (4:1) recorded the higher growth parameters like plant height (127.6 and 133.6 cm at 60 DAS and at harvest stage) and LAI of 5.23 and 4.84 at 60 DAS and at harvest stage, respectively andalso produced higher yield parameters like no.of tillers plant$^{-1}$ (9) andno.of productive tillers (8) with higher grain and stover yield of 1326 and 4109 kg ha$^{-1}$ and it is statistically parallel with $T_4$little millet + green gram (4:1).And also,nutrient uptake was highest (N – 40.8, P – 5.7 and K – 33.5 kg ha$^{-1}$) in little millet + black gram (6:1). Regarding the post harvest soil fertility status, little millet + cowpea (4:1) registered the highest available NPK (339, 47.6 and 197 kg ha$^{-1}$).Therefore, intercropping of black gram or green gram with little millet under rainfed condition would be the ideal recommendation.



*Keywords: Intercropping; little millet;growth and yield; nutrient uptake;row pattern; yield attributes.*


## 1.INTRODUCTION

Little millet (*Panicum sumatrense* L.) which is also known as Samai or Indian millet belongs to the poaceous family and it is originated in Southeast Asia. It is considered as the staple food grain crop for the people in tribal locations of India. The cultivation of little millet is about 2.25 lakh ha with a production and productivity of 1.59 lakh tonnes and 707 Kg ha$^{-1}$in India (Anonymous, 2016).Little millet is highly tolerant to extreme soil and climatic conditions it can withstand under both drought and waterlogging. This crop is well known in Tamil Nadu and grown quite extensively in several parts of the country and this crop is strongly associated with tribal agriculture (Sivagami *et al*., 2020). Small farmers with limited land, water, and financial resources have found that the monocropping system has not been able to meet their diverse needs. As a result, they are turning to alternative, more suitable, and more efficient production systems that have the potential to sustainably increase production per unit area and time while also making proper use of available resources.Growing two or more crops together is the fundamental idea behind an intercropping system. The idea is that two crops can use resources more effectively than one and, in the end, produce the maximum yield because the component crops may use resources differently and when grown together, they complement one another and maximize the use of all resources (Dwivedi *et al*., 2015). In comparison to sole cropping, intercropping systems have the potential to provide advantages through yield management and optimal yield, satisfying the requirements of small farmers and improving weed, pathogen, and insect control as well as soil erosion control.The microclimatic environment within the crop canopy, with respect to light irradiation, is important for crop productivity which can result from either high interception of solar radiation or maximum light use efficiency (Zahedi *et al*., 2015). Because intercropping systems involves growing of tall and short statured crops, a substantial amount of light passes through the plant canopy of tall statured crops to influence plant growth and development.Therefore, the purpose of the present study was to determine the growth and productivity of little millet under an intercropping system with various pulse crops.

## 2. MATERIALS AND METHODS

### 2.1 Locationoftheexperimentalsite

The field experiment was conducted at Instructional North farm, Karunya Institute of Technology and Sciences, Coimbatore. The experimental site is geographically located in the western zone of Tamil Nadu at 11º N latitude and 77º E longitude at an altitude of 427 m above mean sea level.

### 2.2 Climate and weather

The annual rainfall of Coimbatore is 680 mm distributed over 52 rainy days. The mean annual maximum and minimum temperature are about 38.00℃ and 19.41℃ respectively and the mean bright sunshine hours per day are 7.1 hours with the mean evaporation of 6.2 mm.

### 2.3 Soil characteristics

The soil of the experimental field is clay loam with medium in available nitrogen (296 kg $ha^{-1}$) and phosphorus (18 kg $ha^{-1}$) with high in available potassium (285 kg $ha^{-1}$) and 0.68% in organic carbon.

### 2.4 Season and crop varieties

The study was conducted during the season of *rabi* from October 2023 to January 2024. The variety selected for main crop little millet was ATL 1 with a duration of 85-90 days. For intercrops like black gram (VBN 8), green gram (VBN 3), redgram (APK 1), cowpea (CO 2), bengal gram (CO 3) were the selected varieties.

### 2.5. Experimental design

The field trial was laid out in randomized block design (RBD) comprising of three replications and eleven treatments. The treatment details includes: $T_1$ – Little millet sole crop, $T_2$ – Little millet + black gram (4:1), $T_3$ – Little millet + black gram (6:1), $T_4$ – Little millet + green gram (4:1), $T_5$ – Little millet + green gram (6:1), $T_6$ – Little millet + redgram (4:1), $T_7$ – Little millet + redgram (6:1), $T_8$ – Little millet + cowpea (4:1), $T_9$ – Little millet + cowpea (6:1), $T_{10}$ – Little millet + bengal gram (4:1), $T_{11}$ – Little millet + bengal gram (6:1).

### 2.6. Experimental Observations

#### 2.6.1. Plantheight

ThePlantheightoflittle milletwasrecordedat 30, 60 DASandatharvest stage

#### 2.6.2. Leafareaindex

The Leaf area was measured at 30, 60 DAS and at harvest by using leaf area meter and LAI was calculated by the following formula of williams (1946).

$$\text{Leaf Area Index} = \frac{\text{Leaf Area}}{\text{Ground area occupied by the plant } (\text{cm}^2)}$$

#### 2.6.3. Yield parameters

The observations on yield parameters like number of tillers, number of productive tillers, number of grains per panicle, 1000 grain weight, grain yield and stover yield.

#### 2.6.4. Plant and soil analysis

The plant nutrient uptake status was analysedat harvest stage using Microkjeldahl method fornitrogen suggested by Humphries (1956), phosphorus and potassiumwereanalyzed by colorimetric estimation and flame photometric methodgiven by Jackson (1973).Post-harvest soil fertility status wasanalysed by Alkaline permanganate method for available N suggested by Subbiah and Asija (1956), Olsen method for available P given by Olsen *et al*. (1954) and Neutral normal ammonium acetate method for available K given by Stanford and English (1949).

### 2.7. Statistical Analysis

The data collected on various parameters studied during the experiment were subjected to statistical analysis by using ANOVA in randomized block design as given by Gomez and Gomez (1984). Critical difference was worked out at the 5 % probability level wherever the treatments were significant.

## 3. RESULTS AND DISCUSSION

### 3.1 Effect of intercropping on plant height of little millet

The ANOVA result on the plant height revealed that little millet as influenced by pulse interceppingwas non-significant at 30 DAS but the plant height at 60 DAS and at the harvest stage was significantly influenced by various pulse intercropping system and it is presented in Fig.1. At 60 DAS and at harvest the height of the plant was maximum (127.6 cm and 133.6 cm)in $T_2$ – little millet + black gram (4:1) which is remained at par with $T_4$ – little millet + green gram (4:1) with the values of 126.8 and 132.8 cm at 60 DAS and at harvest stage.This is possibly due to the result of non-renewable resources like water, nutrients and incoming sunshine establishing stronger complementary interactions and similar findings were also reported by Sharmili and Parasuraman (2018); Kamani and Arvadiya (2023).The lowest plant height of 96.7 and 99.4 cm was recorded in $T_8$– little millet + cowpea (4:1).

### 3.2 Effect of intercropping on Leaf area index of little millet

The mean values pertaining to leaf area index of little millet under the influence of pulse intercropping system is furnished in Table.1. Among all the treatments, LAI at 30 DAS was not significantly influenced by the intercropping system and at 60 DAS and at harvest stage LAI was statistically significant. The highest LAI of 5.21 and 4.84 at 60 DAS and at harvest stage was observed in $T_2$ – little millet + black gram (4:1) which is statistically on par with $T_4$ – little millet + green gram (4:1) with LAI of 5.08 and 4.55 at 60 DAS and at harvest stage, respectively. The lowest LAI (3.31 and 2.28 at 60 DAS and at harvest) was observed in $T_8$ – little millet + cowpea (4:1). The differences in leaf area index are due to the variations in soil fertility and prevailing environmental circumstances and it also based on the leaf area and leaf count of the plant. Similar findings were reported by Chaudhary*et al.* (2020).

### 3.3 Effect of intercropping on yield attributes of little millet

The yield attributes of little millet *viz*., no.of grains per panicle and 1000 grain weight were notsignificantly influenced by the intercropping system at harvest stage but other attributes like no.of tillers plant$^{-1}$ and no.of productive tillers were influenced significantly and the values were higher in sole crop of little millet recorded 9 tillers plant$^{-1}$and 8 productive tillersplant$^{-1}$, respectively followed by $T_2$- Little millet + black gram (4:1)which was statistically comparable with $T_4$ - Little millet + green gram (4:1) with 8 tillers and 7 productive tillers plant$^{-1}$among all the intercropping treatments.The lowest yield attributes of 5 tillers and 3 productive tillers were observed in $T_8$– Little millet + cowpea (4:1) and the reason behind this is the presence of adequate space, light, nutrients and water along with minimal habitat disturbance. Additionally, maincrop and intercrops are a complementary combination where the intercrop fix atmospheric N which the main crop uses to enhance its growth and yield characteristics and ultimately increasing the yield.Kumar and Ray (2020) observed the same trend of yield attributes on base crop.

### 3.4 Effect of intercropping on yield of little millet

The ANOVAresults on the grain and straw yield of little millet is significantly influenced by the pulse intercropping systems which is presented in Fig2. The highest grain and stover yield (1506 kg ha$^{-1}$ and 4817 kg ha$^{-1}$ respectively) was obtained in $T_1$ - Little millet – sole crop due to higher plant population and followed in comparison with other intercropping treatments the higher grain and stover yield (1326 kg ha$^{-1}$ and 4109 kg ha$^{-1}$, respectively) was observed in $T_2$- Little millet + black gram (4:1) which was on par with $T_4$ - Little millet + green gram (4:1) with the grain and stover yield of 1298 kg ha$^{-1}$ and 4021 kg ha$^{-1}$, respectively. This might be due to the yield attributing characteristics of the crop reveal its yield potential. In an intercropping system, mutualism and complementary relationships between the intercrops which improve the yield characteristics of main crop. An array of aspects including improved space utilization, efficient use of sunlight, nutrients and water, increased N efficiency have been shown to be key factors contributing to the increased yield of little millet.On other hand, the lowest grain and stover yield (797 kg ha$^{-1}$ and 2319 kg ha$^{-1}$) was recorded in $T_8$ - little millet + cowpea (4:1).Similar results were reported by Keerthanapriya *et al*. (2019) and Sharmili& Manoharan (2018).

### 3.5 Effect of intercropping on total nutrient (NPK) uptake

The data on the total NPK uptake is significantly influenced by intercropping system and the total NPK uptake by main crop and intercropsare furnished in Table 3. The total NPK uptake of little millet was maximum (NPK - 40.8, 5.7 and 33.5 kg ha$^{-1}$) when intercropped withblack gram at 6:1 ratio which was remained at par with black gram (4:1) and green gram (4:1 and 6:1). This may be due to the uptake of NPK by little millet was higher when intercropped with black gram and green gram and also due to the effective root system which may uptake higher concentration of nutrients even from deeper layer of the soil. The findings from this study shows that effective transfer of N from legumes to maincrop, which improves both the N uptake in cereals and $N_2$ fixations in pulses, is primarily responsible for the increase in nutrient N, particularly in base crop under cereal + legume intercropping condition. similar trend for nitrogen uptake was followed by Sharmili and Manoharan (2018).

### 3.6 Effect of intercropping on post harvest soil fertilitystatus

The data pertained to post harvest soil fertility under the effect of pulse intercropping on little millet was statistically significant and it is furnished in Table 4. The post-harvest soil fertility status was found to be higherin little millet + cowpea (4:1)(339, 47.6 and 197 kg ha$^{-1}$). The reason for this is due to the uptake of nutrients by the plant and the higher K availability might be due to the deep tap rooted legume plants can take K from the lower soil layers and replenish the surface soil by releasing nutrient rich leaves that break down and release nutrients.The lower values of available NPK (271, 21.3 and 121 kg ha$^{-1}$) was recordedin little millet + black gram (6:1). Similar trend was reported by Chaithanya *et al*. (2020).

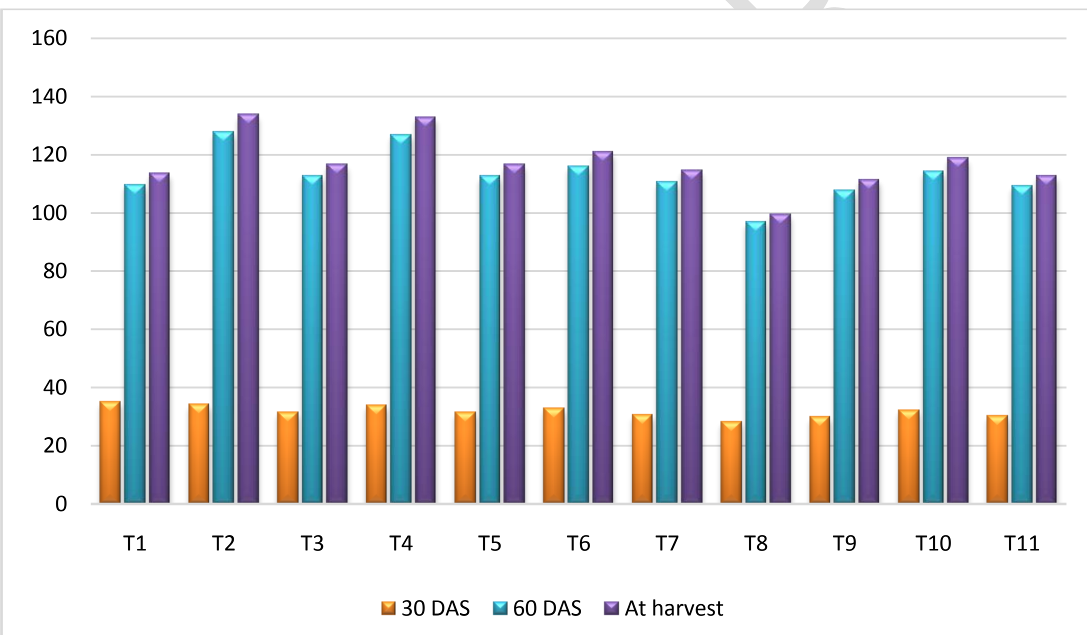


**Fig. 1. Effect of intercropping on plant height of little millet**

*$T_1$ - Little millet- sole crop; $T_2$ - Little millet + Black gram (4:1); $T_3$ - Little millet + Black gram(6:1); $T_4$ - Little millet + Green gram (4:1); $T_5$ - Little millet + Green gram (6:1);$T_6$ - Little millet + Redgram (4:1); $T_7$ - Little millet + Redgram (6:1); $T_8$ - Little millet + Cowpea (4:1); $T_9$ - Little millet + Cowpea (6:1); $T_{10}$ - Little millet + Bengal gram (4:1);$T_{11}$ -Little millet + Bengal gram (6:1)*

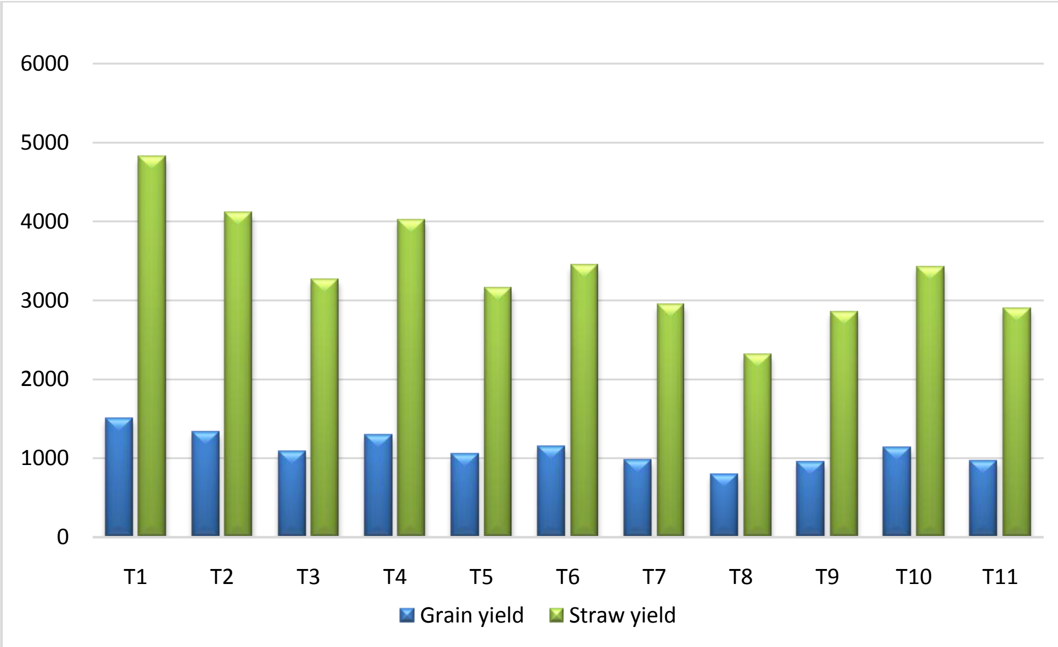


**Fig. 2. Effect of intercropping on grain and straw yield of little millet**
*$T_1$ - Little millet- sole crop; $T_2$ - Little millet + Black gram (4:1); $T_3$ - Little millet + Black gram (6:1); $T_4$ Little millet + Green gram (4:1); $T_5$ - Little millet + Green gram (6:1); $T_6$ - Little millet + Redgram (4:1); $T_7$ - Little millet + Redgram (6:1); $T_8$ - Little millet + Cowpea (4:1); $T_9$ - Little millet + Cowpea (6:1); $T_{10}$ - Little millet + Bengal gram (4:1); $T_{11}$ -Little millet + Bengal gram (6:1)*

**Table 1. Effect of intercropping on Leaf area index of little millet**

| | Treatments | 30 DAS | 60 DAS | At harvest |
|---|---|---|---|---|
| $T_1$ | Little millet- sole crop | 0.48 | 4.46 | 3.67 |
| $T_2$ | Little millet + Black gram (4:1) | 0.47 | 5.23 | 4.84 |
| $T_3$ | Little millet + Black gram (6:1) | 0.42 | 4.08 | 3.29 |
| $T_4$ | Little millet + Green gram (4:1) | 0.46 | 5.08 | 4.55 |
| $T_5$ | Little millet + Green gram (6:1) | 0.42 | 4.05 | 3.26 |
| $T_6$ | Little millet + Redgram (4:1) | 0.45 | 4.32 | 3.38 |
| $T_7$ | Little millet + Redgram (6:1) | 0.41 | 3.92 | 2.96 |
| $T_8$ | Little millet + Cowpea (4:1) | 0.30 | 3.31 | 2.28 |
| $T_9$ | Little millet + Cowpea (6:1) | 0.40 | 3.85 | 2.86 |
| $T_{10}$ | Little millet + Bengal gram (4:1) | 0.43 | 4.29 | 3.34 |
| $T_{11}$ | Little millet + Bengal gram (6:1) | 0.41 | 3.88 | 2.89 |
| | SE(d) | 0.05 | 0.24 | 0.21 |
| | CD (5%) | NS | 0.51 | 0.44 |

**Table 2. Effect of intercropping on yield attributes of little millet**

| | Treatments | No. of tillers plant$^{-1}$ | No. of productive tillers | No. of grains per panicle | 1000 grain weight |
|---|---|---|---|---|---|
| $T_1$ | Little millet- sole crop | 9 | 8 | 249 | 2.45 |
| $T_2$ | Little millet + Black gram (4:1) | 8 | 7 | 257 | 2.48 |
| $T_3$ | Little millet + Black gram (6:1) | 6 | 5 | 241 | 2.42 |
| $T_4$ | Little millet + Green gram (4:1) | 8 | 7 | 254 | 2.47 |
| $T_5$ | Little millet + Green gram (6:1) | 6 | 5 | 238 | 2.42 |
| $T_6$ | Little millet + Redgram (4:1) | 7 | 6 | 247 | 2.44 |
| $T_7$ | Little millet + Redgram (6:1) | 6 | 4 | 234 | 2.41 |
| $T_8$ | Little millet + Cowpea (4:1) | 5 | 3 | 225 | 2.38 |
| $T_9$ | Little millet + Cowpea (6:1) | 6 | 4 | 229 | 2.40 |
| $T_{10}$ | Little millet + Bengal gram (4:1) | 7 | 6 | 244 | 2.43 |
| $T_{11}$ | Little millet + Bengal gram (6:1) | 6 | 5 | 232 | 2.39 |
| | SE(d) | 0.4 | 0.4 | 14.6 | 0.2 |
| | CD (5%) | 0.8 | 0.8 | NS | NS |

**Table 3. Total nutrient uptake as influenced by intercropping (kg ha$^{-1}$)**

| | Treatments | Total N uptake | Total Puptake | Total K uptake |
|---|---|---|---|---|
| $T_2$ | Little millet + Black gram (4:1) | 39.1 | 5.4 | 31.7 |
| $T_3$ | Little millet + Black gram (6:1) | 40.8 | 5.7 | 33.5 |
| $T_4$ | Little millet + Green gram (4:1) | 38.7 | 5.2 | 31.4 |
| $T_5$ | Little millet + Green gram (6:1) | 40.5 | 5.6 | 33.2 |
| $T_6$ | Little millet + Redgram (4:1) | 31.6 | 3.2 | 20.2 |
| $T_7$ | Little millet + Redgram (6:1) | 33.2 | 3.8 | 20.6 |
| $T_8$ | Little millet + Cowpea (4:1) | 16.6 | 2.0 | 13.8 |
| $T_9$ | Little millet + Cowpea (6:1) | 18.5 | 2.4 | 15.1 |
| $T_{10}$ | Little millet + Bengal gram (4:1) | 21.0 | 3.0 | 21.5 |
| $T_{11}$ | Little millet + Bengal gram (6:1) | 21.3 | 3.4 | 22.8 |
| | SE(d) | 2.85 | 0.40 | 2.49 |
| | CD (5%) | 5.99 | 0.85 | 5.22 |

**Table 4. Post harvest soil fertility status (kg ha$^{-1}$)**

| | Treatments | Available N | Available P | Available K |
|---|---|---|---|---|
| $T_1$ | Little millet- sole crop | 324 | 35.4 | 172 |
| $T_2$ | Little millet + Black gram (4:1) | 278 | 24.6 | 159 |
| $T_3$ | Little millet + Black gram (6:1) | 271 | 21.3 | 121 |
| $T_4$ | Little millet + Green gram (4:1) | 283 | 27.2 | 173 |
| $T_5$ | Little millet + Green gram (6:1) | 276 | 23.5 | 162 |
| $T_6$ | Little millet + Redgram (4:1) | 310 | 27.8 | 179 |
| $T_7$ | Little millet + Redgram (6:1) | 302 | 29.6 | 166 |
| $T_8$ | Little millet + Cowpea (4:1) | 339 | 47.6 | 197 |

| | | | | |
|---|---|---|---|---|
| $T_9$ | Little millet + Cowpea (6:1) | 333 | 42.8 | 168 |
| $T_{10}$ | Little millet + Bengal gram (4:1) | 323 | 36.2 | 194 |
| $T_{11}$ | Little millet + Bengal gram (6:1) | 319 | 33.4 | 167 |
| | SE(d) | 21.81 | 2.6 | 7.8 |
| | CD (5%) | 45.49 | 5.4 | 16.3 |

## 4. CONCLUSION

Thefindingsofthestudyrevealedthatlittlemillet + blackgramorlittlemillet + greengramattherowratioof 4:1 isbeneficialamongotherpulsecropsintermsofgrowthattributes*viz*., plantheight, leafareaindex, productivityandsoilnutrientuptake. Itcanbeconcludedthatlittlemillet+ blackgrammightbethebestintercroppingcombinationforrainfedconditionandlittlemillet + greengramintercroppingsystemalsobeagoodsubstitute.

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## REFERENCES

1. Anonymous. 2016. Agricultural census, Directorate of economics and Statistics, Department of Agriculture and Cooperation, Government of India.
2. Chaithanya, J., Arvadiya, L. K., andMadagoudra, Y. B. (2020). Effect on yield and soil fertility status of summer sorghum (Sorghum bicolor L.) under sole crop and different inter cropping systems. *IJCS*, *8*(6), 3046-3049.
3. Chaudhary, R., Gupta, S. K., Singh, M. K., and Kohli, A. (2020). Effect of intercropping on growth, yield and profitability of sorghum, pearl millet and cowpea. Journal of Pharmacognosy and Phytochemistry, 9(5S), 179-182.
4. Dwivedi A, Dev I, Kumar V, Yadav RS, Yadav M, Gupta D, et al. Potential role of maize-legume intercropping systems to improve soil fertility status under smallholder farming systems for sustainable agriculture in India. International Journal of Life Sciences Biotechnology and Pharma Research. 2015; 4(3):145.
5. Gomez, K. A., and Gomez, A. A. (1984). Statistical procedures for agricultural research. John wileyand sons.
6. Humphries, E.C. (1956). Mineral Components and Ash Analysis. In: Paech, K., Tracey, M.V. (eds) Modern Methods of Plant Analysis / Moderne Methoden der Pflanzenanalyse. Modern Methods of Plant Analysis / Moderne Methoden der Pflanzenanalyse, vol 1. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-80530-1_17.
7. Jackson, M.L. (1973). Soil chemical analysis. New Delhi: Prentice Hall of India Pvt. Ltd.
8. Kamani, H. A., and Arvadiya, L. K. (2023). Growth, yield attributes and yield of pearl millet as influenced by pearl millet based intercropping system with different levels of nitrogen.
9. Keerthanapriya, S., Hemalatha, M., Joseph, M., &Prabina, B. J. (2019). Assessment of competitiveness and yield advantages of little millet based intercropping system under rainfed condition. IJCS, 7(3), 4121-4124.
10. Kumar, B., and Ray, P. K. (2020). Performance of intercropping of legumes with finger millet (Eleusine coracana) for enhancing productivity, sustainability and economics in Koshi region of Bihar. *Journal of Pharmacognosy and Phytochemistry*, *9*(3), 1568-1571.
11. Olsen, S. R. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate (No. 939). US Department of Agriculture.
12. Sharmili, K., and Manoharan, S. (2018). Studies on intercropping in rainfed little millet (Panicum sumatrense). International Journal of Current Microbiology and Applied Sciences, 7(2), 323-327.
13. 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.
14. Sivagamy, K., Ananthi, K., Kannan, P., Vijayakumar, M., Sharmili, K., Rajesh, M., ... and Parasuraman, P. (2020). Studies on Agro Techniques to Improve the Productivity and Profitability of Samai+ Red gram Intercropping System under Rainfed Conditions. International. Journal of Current. Microbiology and applied. Sciences, 9(6), 4126-4130.
15. Stanford, S., and English, L. (1949). Use of flame photometer in rapid soil tests for K and Ca. Agronomy Journal, 41(7), 446-447.
16. Subbiah, B.V., and Asija, C.L. (1956). A rapid procedure for the estimation of available Ninsoils. 25, 259–260.
17. WILLIAMS, R. F. (1946). The Physiology of Plant Growth with Special Reference to the Concept of Net Assimilation Rate. Annals of Botany, 10(37), 41–72. http://www.jstor.org/stable/42906970.

18. M. Zahedi, F. Mondani, H.R. Eshghizadeh, Analyzing the energy balances of double-cropped cereals in an arid region, Energy Rep. 1 (2015) 43–49.