Economic advantage of Sorghum based Intercropping system for Western zone of Tamil Nadu

Abstract

Sorghum is the fifth most important crop. Being a C_4 crop, it can withstand adverse climatic conditions. It can be used for food, feed, fodder, and biofuel. Sorghum can perform better under future climatic conditions than other crops and can be a better option in the future that can ensure the food and nutritional security of the country. A sorghum-based intercropping system can be a great option to ensure sustainability by fetching additional income from legume crops without compromising the yield of sorghum. An experiment was conducted at Tamil Nadu Agricultural University during the summer of 2021 to evaluate the economic benefits of a sorghum-based intercropping system. The treatment consists of T_1-Sorghum. Sole crop, T_2-2rows of Sorghum+2rows of Cowpea, T_3-2rows of Sorghum+1row of Cowpea, T_4-2rows of Sorghum+2rows of Greengram, T_5-2rows of Sorghum+1rows of Greengram, T_6-2rows of Sorghum+2rows of Lablab, T_7-2rows of Sorghum+1rows of Lablab. The economic benefits of the cropping system were evaluated by considering the yield, BCR, and LER. The yield of sorghum (3 t ha^{-1}) planted under T_7 was significantly higher than that of sole sorghum (T_1). The net return from T_7 (₹ 67872 ha^{-1}) was higher than other treatments because of the additional income generated from the lablab (high market value at the time of harvest). The B:C ratio of the intercropping system was 2.7, whereas sole sorghum registered the lowest BCR of 1.9. The compatible performance of the intercropping system yielded a higher net return and BCR. Hence, intercropping of sorghum with legumes (especially lablab) is more productive and remunerative under a 2:1 pattern compared to sole cropping.

Keywords: sorghum, intercropping, yield, net return, benefit-cost ratio

Introduction

India is the seventh-largest country with a geographical area of 328.7 million ha. Agriculture is an important sector that contributes about 17% of the gross domestic product and playpivotal role in a country's employment opportunities. The rapid increase in population and diminishing fertile land necessitate that agriculture researchers find the effective row ratio of component crops in intercropping systems for maximum utilization of the available resources.

The intercropping of crops with different photosynthetic pathways can increase the efficiency of available resources, such as land. The sorghum-based intercropping system is a popular climate-smart technology for rain-fed areas of India. It reduces the risk of yield loss and economic return. The intercropping system ensures soil fertility and sustainability. Selecting the appropriate row ratio or cropping pattern determines the overall efficiency of the system by significantly affecting the productivity and resource utilization of the crops.

Intercropping in addictive series has a yield advantage over the replacement series, but maintaining high plant density in addictive series also has a pernicious effect on yield. Triveni *et al*. (2017) observed that the yield of pearl millet was higher than that of sole pearl millet. Under the intercropping system, the pearl millet sown with cowpea in a 2:2 pattern had a higher yield. The competition exhibited by groundnut under pearl millet and groundnut in a 1:1 planting pattern reduced the yield of pearl millet. The maize planted with legumes in a 2:2 pattern was found to be more remunerative than a 2:1 pattern (Kheroar and Patra, 2014). Similarly, the mixed cropping of sorghum with guinea grass yielded 2.4 times more monetary return compared with sole cropping (Borghi et al. 2013). The row proportion also has a significant impact on the land-equivalent ratio. The LER is used to assess the effective utilization of land by intercrops compared with sole crops. Musa et al. (2021) observed that the highest LER of (1.4) was obtained in sorghum planted with soybeans in a 3:3 proportion. Similarly, sorghum with lablab had an 87% higher LER than the sole sorghum (Kahsay et al., 2021).Hence, the present study was conducted to find out the effective sorghum-legume intercropping system by mainly considering their yield and economic attributes for the western zone of Tamil Nadu.

Materials and Method

The field experiment was conducted during March–June 2021 in the Eastern Block of Tamil Nadu Agriculture University with latitude (11º01’ N) and longitude (76º93E) at an altitude of 426.7 mm above the Mean Sea Level (MSL). The sorghum was raised as a sole crop and also intercropped with legumes such as green gram, cowpea, and lablab under a 2:1 and 2:2 ratio to find the economic benefits of an intercropping system over a sole crop. The experiment consisted of seven treatments and was replicated three times. The treatment and variety details are summarized in Table 1. The sole sorghum was planted with a spacing of 45 x 15 cm and a population of 1, 55, 555 plants per ha. The addictive series was followed by an intercropping system. In 2:1 intercropping, sorghum was sown in a paired row at 30/60 cm. One row of intercrop (greengram, chickpea, or lablab) was sown in between two paired rows of sorghum with a spacing of 30 cm from the sorghum lines. In 2:2 ratio intercropping, sorghum was sown in a paired row at 30/60 cm. Two rows of intercrop (greengram, cowpea, and lablab) were sown in between two paired rows of sorghum with a spacing of 15 cm from the sorghum lines and maintaining an equivalence distance of 30 cm between pulses line. The plant density under 2:1 was 1,32,066 plants/ha, and under the 2:2 pattern, it was 1,36,068 plants/ha. The recommended NPK 90:45:45 was adopted. The entire dose (100%) of P_2O_5 and K_2O was applied basally before planting. The N was applied in split doses of 50:25:25% at 0, 15, and 30 days after sowing, respectively. During the study period, the total amount of rainfall received was 73.5 mm, with eight rainy days. The mean maximum temperature was 34.1 °C, and the mean minimum temperature was 23.8 °C. The mean maximum and minimum relative humidities were 81.4% and 46.6%, respectively.

Data collection

To study the economic returns from the treatments, parameters such as grain yield, stover yield, net returns, Benefit Cost ratio, and Land Equivalent ratio were taken into consideration and calculated as follows:

Harvesting was done at physiological maturity. For pulses, the mature pods were harvested manually, whereas for sorghum, the ear heads were harvested first and the stalks were harvested a week later. The crops in individual treatments were harvested separately and weighed. The yield was recorded and expressed in kg ha^{-1}. The stover was weighed, and the stover yield was recorded in kg ha^{-1}.

Gross return: The gross yield of each treatment was calculated and expressed as ₹ ha^{-1}

$$\text{Gross return}(\ \text{ha}^{-1}) = \text{Economic yield}(\text{kg ha}^{-1}) \times \text{Market Value of produce}(\ \text{ha}^{-1})$$

Net return: The net return of each treatment was calculated and expressed in ₹ ha^{-1}

$$\text{Net return}(\ \text{ha}^{-1}) = \text{Gross return}(\ \text{ha}^{-1}) - \text{Cost of Cultivation}(\ \text{ha}^{-1})$$

Benefit-Cost ratio (BCR): The benefit-cost ratio was calculated as

$$\text{Bene it} - \text{Cost Ratio} = \frac{\text{Gross return}(\ \text{ha}^{-1})}{\text{Cost of cultivation}(\ \text{ha}^{-1})}$$

Land Equivalent ratio (LER)

The benefits of intercropping in utilization of resources against their monocropping can be assessed by LER. This was given by Willey (1979)and it is defined as the land unit area required under pure stand of species to yield the same product as obtained under intercropping at the same management level (Mead and Willey (1980) and Willey (1985)). LER of 1.3 indicates a yield advantage of 30 percent (i.e., 30 percent more landwould be required as sole stand to produce the same yield as intercropping). The LER was calculated as

$$LER = \frac{Yield\ of\ Sorghum\ as\ intercrop}{yield\ of\ Sorghum\ as\ sole\ crop}$$

Results

Grain yield and stover yield

Table 1. Grain and Stover yield of sorghum under different intercropping system

Treatments	Grain Yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1 - Sorghum sole cropping	2696^{d}	8617.0^{d}
T_2 - Paired row of Sorghum + 2 rows of Cowpea (2S:2C)	2440^{e}	8531.0^{d}
T_3 - Paired row of Sorghum + 1 row of Cowpea (2S:1C)	2939^{b}	9218.0^{b}
T_4 - Paired row of Sorghum + 2 rows of Greengram (2S:2G)	2767^{c}	8896.0^{c}
T_5 - Paired row of Sorghum + 1 row of Greengram (2S:1G)	2744^{d}	9005.0^{c}
T_6 - Paired row of Sorghum + 2 rows of Lablab (2S:2L)	2623^{d}	8871.0^{c}
T_7 - Paired row of Sorghum +1 row of Lablab (2S:1L)	3077^{a}	9227.0^{a}
SEd	59.8	146.01
CD (0.05)	130.4**	318.13**

** Highly Significant
Mean followed by same alphabets are not significant at $p<0.05$

The sorghum planted with lablab under the 2:1 pattern registered the highest grain yield of 3077 kg ha^{-1}, followed by the sorghum planted with cowpea under the 2:1 pattern. The grain yield of sorghum under the different treatments is presented in Table 1. There was a 14% higher yield of sorghum in T_7 than sole sorghum. The sorghum yield planted with cowpea under a 2:2 row ratio (T_2) registered a lower grain yield than sole sorghum. The sorghum under the intercropping system was well benefited by the complementary effect of legume rows, which resulted in a higher yield than the sole crop, except for T_2 (2:2 rows of sorghum and cowpea) and T_6 (2:2 rows of sorghum and lablab). The cowpea and lablab under a 2:2 pattern competed with sorghum for resources such as light, which reduced the yield of the sorghum under intercropping (Dharshini *et al*., 2022).

Economic Efficiency

The cost of cultivation was worked out based on the market value provided at https://agmarknet.gov.in/. There was a significant difference in the net return and benefit cost ratio obtained from each treatment (Figs. 1 and Fig. 2). The net return was higher in T_7 (₹ 67872 ha^{-1}), followed by T_6 (₹ 56431 ha^{-1}). The net return obtained was the lowest in sole Sorghum T1 (₹ 25315 ha^{-1}). The higher market value of Lablab (₹ 45 per kg) than other intercrops fetched the additional return from T_7 and T_6. The low market value of cowpea (₹ 15.0) had reduced the net return from T_3 despite having the second highest yield. Overall, the net return from the intercropping system was higher than sole Sorghum (T_1). The compatible performance of intercrop yielded a higher net return (Ananthi *et al*., 2019). The BCR was highest under the 2:1 pattern of sorghum planted either with lablab or green gram. The intercropping was more productive and remunerative compared to the sole cropping, which resulted in a higher B:C ratio than T_1 (Khan *et al*., 2018).

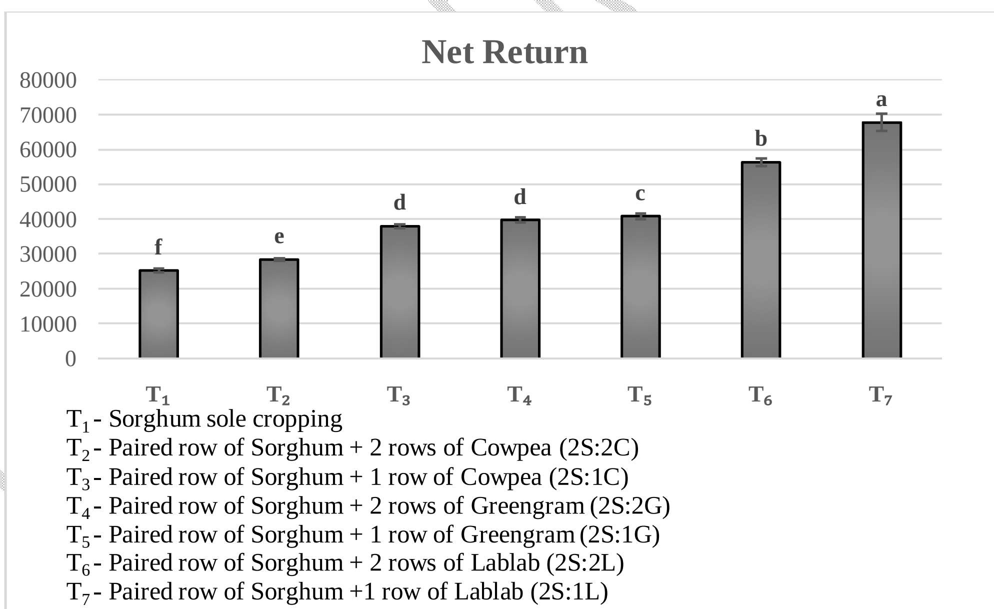

Fig.1Net return from sorghum under different intercropping system

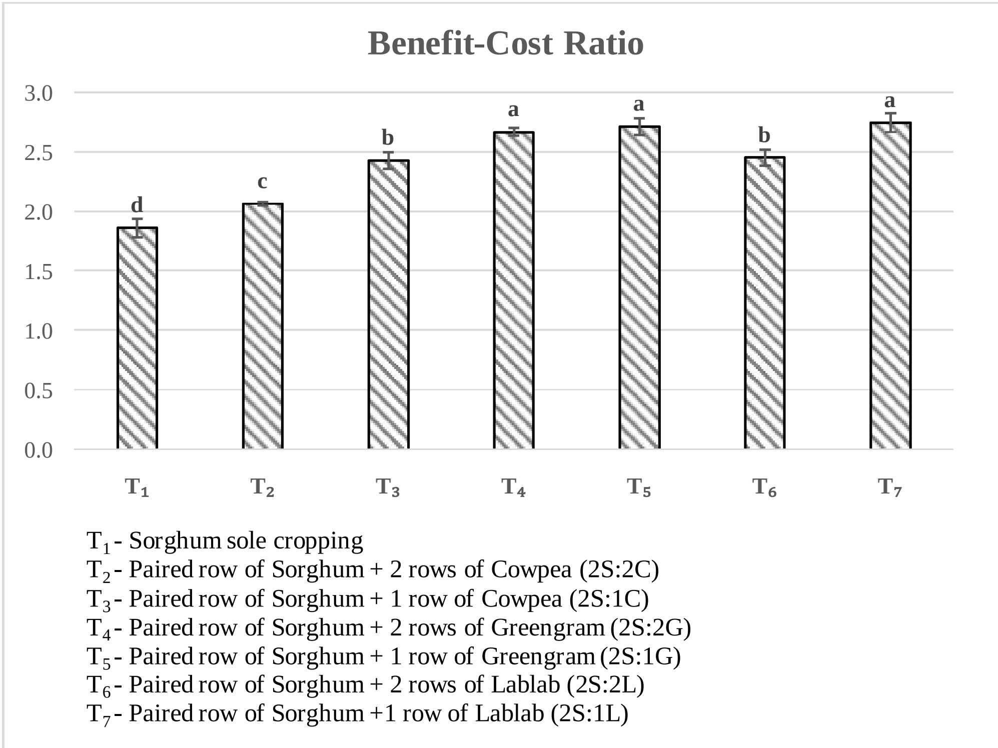

Fig.2Benefit-Cost Ratio under different intercropping system

Land Equivalent Ratio (LER)

There was a significant difference in the LER of sorghum under different planting patterns (Fig. 3). The sorghum under T_7 had the highest LER of 1.14, followed by T_3 (1.09). The sorghum under T_6 and T_2 registered LER values of 0.97 and 0.91, which were less than 1. The beneficial effect of lablab in T_7 exhibited less competition, which resulted in enhanced productivity (Atabo and Umaru, 2015). The LER value of more than 1 indicated the efficient utilization of land by intercrops. The LER values obtained from T_6 and T_2 were less than 1. The high density of cowpea, green gram, and lablab maintained in a 2:2 pattern (T_2, T_4, T_6) reduced the LER compared to their respective 2:1 pattern (T_3, T_5, T_7). The same was supported by Ribas*et al*. (2020).

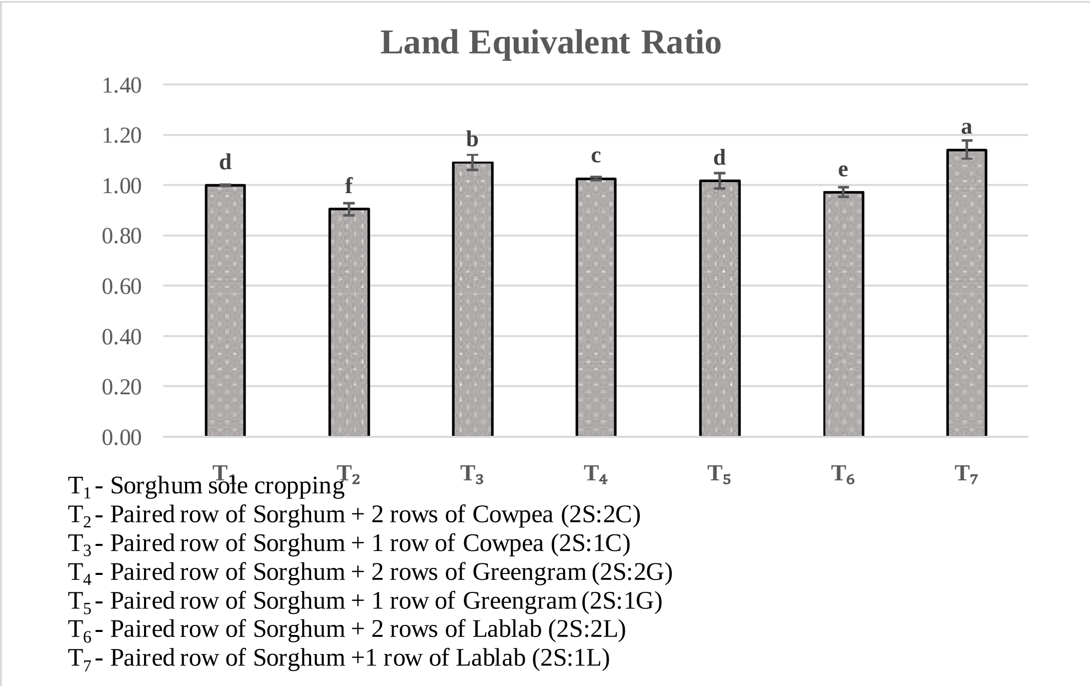

Fig.3Land Equivalent Ratio under different intercropping system

Conclusion

The grain yield from sorghum planted under a 2:1 pattern with lablab resulted in a 14% higher grain yield. The additional yield benefit is due to the complementary effect exhibited by the intercrops on sorghum. The high density maintained under the 2:2 pattern and spreading nature of cowpea exhibited dominance over sorghum, which was reflected in the grain and stover yield. The monetary return, BCR, and LER from T_7 were also found to be significantly higher than all other treatments. It is concluded that for the western region of Tamil Nadu, intercropping sorghum under 2:1 is more beneficial than the 2:2 pattern. To harness the maximum yield and return, the best option is to intercrop sorghum with lablab in a 2:1 pattern.

References

1. Ananthi, T, Mohamed Amanullah M, and C Vennila. 2019. "Economics of Different Intercropping Systems of Maize under Mycorrhizal Inoculation and DifferentFertilizer Levels." *Current Journal of Applied Science and Technology* 37 (2):1-10.
2. Atabo, J, and T Umaru. 2015. "Assessing the land equivalent ratio (LER) and stability of yield of two cultivars of sorghum (*Sorghum bicolor* L. Moench)-soyabean (*Glycine*

max L. Merr) to row intercropping system." *Journal of Biology, Agriculture and Healthcare* 5 (18):144-149.

3. Borghi, E, C Crusciol, A Nascente, V Sousa, P Martins, G Mateus, and C Costa. 2013. "Sorghum grain yield, forage biomass production and revenue as affected by intercropping time." *European Journal of Agronomy* 51:130-139.
4. Dharshini, S. D., Ramanathan, S. P., & Kokilavani, S (2022). Assessments of the Effects of Legume Species Intercropping on Radiation Use Efficiency of Sorghum.*International Journal of Plant & Soil Science*34(4): 18-25
5. Kahsay, R, Y Ekuriaw, and B Asmare. 2021. "Effects of inter-cropping lablab (*Lablab purpureus*) with selected sorghum (*Sorghum bicolor*) varieties on plant morphology, sorghum grain yield, forage yield and quality in Kalu District, South Wollo, Ethiopia." *Tropical Grasslands-ForrajesTropicales* 9 (2):216-224.
6. Khan, M, N Sultana, N Akter, M Zaman, and M Islam. 2018. "Intercropping gardenpea (*Pisium sativum*) with Maize (Zea mays) at farmers' field." *Bangladesh Journal of Agricultural Research* 43 (4):691-702.
7. Kheroar, S, and B Patra. 2014. "Productivity of maize-legume intercropping systems under rainfed situation." *African Journal of Agricultural Research* 9 (20):1610-1617.
8. Maitra, S.; Shankar, T.; Banerjee, P. Potential and advantages of maize-legume intercropping system, In Maize—Production and Use; Hossain, A., Ed.; Intechopen, London, United Kingdom; 2020, doi:10.5772/intechopen.91722.
9. Mead, R. and Willey, R.W. (1980). The concept of a land equivalent ratio and advantages in yields from intercropping. Experimental Agriculture 16:217-228.
10. Musa, M, K El-Aref, M Bakheit, and A Mahdy. 2021. "Effect of intercropping and plant distribution of sorghum with soybean on growth and yield of *Sorghum bicolor*." *Archives of Agriculture Sciences Journal* 4 (1):228-239.
11. Ribas, RGT, AB Cecílio Filho, AF Dutra, JC Barbosa, and GdS Rolim. 2020. "Land Equivalent Ratio in the Intercropping of Cucumber with Lettuce as a Function of Cucumber Population Density." *Agriculture* 10 (3):88.
12. Triveni, B, AM Babu, GP Reddy, and V Munaswamy. 2017. "Effect of Intercropping Systems on Yield Attributes and Yield of Pearlmillet with Grain Legumes under Rainfed Conditions." *Int. J. Curr. Microbiol. App. Sci* 6 (11):3567-3571.
13. Willey, R.W. (1979). Intercropping — its importance and research needs. 1. Competition and Yield Advantages. Field Crop Abstract, 32: 1-10,73-85. Willey,

R.W. (1985). Evaluation and presentation of intercropping advantages. Experimental Agriculture, 21: 119-133.