**Optimizing Land Use, Yield and Profitability Through Early Summer Intercropping in Sugarcane in Northern Telangana, India**

**ABSTRACT**

To increase the area, production and productivity of sugarcane and intercrops and for doubling the farmers income a field experiment was conducted at Regional Sugarcane and Rice Research Station, Rudrur, during 2020-2022 to study the land utilization efficiency, productivity and profitability of early summer intercrops in Sugarcane. Six crops *viz.,* greengram, blackgram, sesame, clusterbean, tomato and coriander were grown as intercrops. Among these, sugarcane intercropped with greengram (1:3) recorded 165.3 t/ha cane equivalent yield which was 13.5 % more over sole sugarcane crop yield (142.9 t/ha). This intercropping systems recorded net returns of Rs. 2,60,964/- which was Rs. 58768/- more over sole sugarcane crop net returns (Rs. 2,02,208/-). The Sugarcane + greengram (1:3) intercropping system recorded highest BC ratio of 2.28 as compared to sole sugarcane crop BC ratio (2.11).

**Key words:** land utilization efficiency, Sugarcane, Intercropping, Sole crop, Cane Yield

**Introduction**

“Sugarcane (*Saccharum officinarum*), an important agro-industrial crop in the country, plays a pivotal role in national economy by contributing 1.9 per cent to agricultural gross domestic product. In India it is grown in an area of 5.00 million hectares with a production of 419.25 million tonnes and the average productivity is 81.98 t ha-1. However, plateauing yield level, declining factor productivity, increasing production cost, slashing sugar prices in international market and decreasing profitability in recent years indeed pose the real concerns before cane growers and mill owners. These necessitated the intensification of sugarcane-based production system through diversification in space and time to meet the multiple needs of cane farmers and maintain long-term soil health. Sugarcane characteristically widely spaced, the row to row distance ranges from 75 to 150 cm” (Chogatapur, S. V., Deepa, G. S., & Chandranath, H. T. 2017). “Initially sugarcane is a slow growing up to 80 to 90 days, its efficient root-system helps to tap plant nutrients and moisture from deeper layers allowing the intercrops to feed at top layers of the soil, of long duration and one-time income generating crop - lends ample scope for intercropping with short-duration, high-value and mid-season income generating crops for household nutrition and economic security, especially of small and marginal cane growers” (Maqsood *et al.* 2005). “It is an excellent technique to increase total yield, higher monetary return, greater resource utilization and fulfill the diversified needs of farmers” (Singh *et al.* 2009). “In intercropping, each crop must have adequate space to maximize cooperation and minimize competition between them. Thus, four things such as spatial arrangement, density, maturity date of the crops being grown, and plant architecture should be considered. Different intercrops such as potato, mustard, onion, lentil, tomato, garlic, chickpea, coriander, greengram, blackgram etc., has long been intercropped in sugarcane. Intercropping also improves nutritional quality of diet for the farm family, allows better control of weeds, increases land equivalent ratio (Imran *et al.* 2011) and has some beneficial effects on pest and disease control” (Obaidul et al., 2018). It is documented that “intercropping in sugarcane with short duration crops is agronomically advantageous and could provide additional income” (Khippal et al., 2016).

**Materials and Methods**

A field experiment was conducted at Regional Sugarcane and Rice Research Station, Rudrur (India) from 2020-2022 situated at an altitude of 286.3 m above mean sea level (AMSL) at 180 49’41” N latitude and 78056’45” E longitude. The experimental site is in Northern Telangana agro climatic zone of Telangana state, India and experiences semiarid climate. According to Trolls classification, the site falls under semi arid tropics (SAT). The long-term (2020-2022) temperature and precipitation data of the site, collected from weather station (RS&RRS, Rudrur, station). The climate is subtropical-monsoonal with an average rainfall of 1059 mm, 70-80% of which occurs during June to September. The summer months are very hot with maximum temperature ranging from 40 to 450C in April and May whereas, December and January are the coldest months (lowest January temperature as low as 13-15 0C). The weekly mean relative humidity ranged from 50.9 to 83.1 5 while average relative humidity was 72.5 %. Prior to the start of experiment, a composite soil sample from 30 cm depth was analyzed for various physicochemical characteristics of the soil. For analysis of nitrogen (N), phosphorous (P) and potash (K) soil sampling was done after the harvest of the crop. Texturally, the soil in the study site was heavy black soil in the 0–30 cm soil layer. The bulk density of the soil was determined by drying the samples in oven at 105 °C for 24 h and recorded 1.02. The pH of soil is 7.54 and organic carbon 0.41% with EC of 0.153 d Sm-1. The soil was low (198.5 kg N ha-1), medium (42.07 kg P2O5 kg ha-1) and high (290.7 kg K2O ha-1) in available nitrogen, phosphorus and potassium, respectively. The experiment was laid out in a Randomized Block Design with seven treatments *viz.,*T1: Sole Sugarcane, T2: Sugarcane + Greengram, T3: Sugarcane+ Blackgram, T4: Sugarcane + Sesame, T5: Sugarcane+ Clusterbean, T6: Sugarcane + Tomato and T7: Sugarcane + Coriander. Each plot (9 x 9 m) was separated by 1m of transition zone while replication was demarcated by a buffer zone of 1.5 m in between. Recommended dose of fertilizers (RDF) were applied at the rate of 250:100:120 kg ha-1 to the main crop. Except at basal application (broadcasted), top dressing was done by spot application of fertilizers at 5 cm below soil. The crop variety selected was ‘Co 86032’ which has high profuse tillering nature. Tiller count was taken at 90 and 120 DAP. Cane length, single cane weight and cane yield was recorded at the time of harvest. Intercrop yield data was recorded at harvest of each intercrop. The data were analyzed statistically by applying the technique of analysis of variance for randomized block design and significance was tested by F-test. Critical difference for treatment means tested for their significance was calculated at 5% level of probability.

**Results and Discussions**

**Tiller count at 90 and 120 days after planting (‘000/ha):**

Data pertaining to tiller count as influenced by different intercrops were presented in table 1. The mean tiller count of three years from 2020 to 2022 shows that sole sugarcane (92.82) recorded statistically superior tiller count at 90 Days After Planting (DAP) and it was on par with all intercrops except tomato (71.05) and sesame (55.63). The tiller count recorded at 120 DAP indicated that sole sugarcane (116.7) recorded the highest number of tillers and it is comparable with all the intercrops except sesame (73.75). Lowest number of tiller count was recorded in sugarcane intercropped with sesame both at 90 and 120 DAP. This reduction in tiller count may be due to this may be due to shade effect of sesame which produces more biomass. The current result was in agreement with works of Khippal *et al.* (2016).

**Number of milleable canes (000/ha):**

Data regarding NMC was presented in table 2. Number of milleable canes were significantly influenced by different intercrops in sugarcane. Sole sugarcane recorded higjhest number of milleable cane (99.73) and it was superior over sugarcane + clusterbean (81.76) and sugarcane + sesame (73.16). However it was on par with sugarcane + greengram (98.3), sugarcane + coriander (92.52), sugarcane + blackgram (90.55) and sugarcane + tomato (89.29). Similar results were also reported by Singh *et al.* (2010) and Kumar *et al.* (2006). However, among the intercrops greengram recorded significantly highest milleanle canes and it was on par with all intercrops except sesamum (73.16).

**Single cane weight (kg/cane):**

The perusal data regarding effect of inter crops on single cane weight was presented in Table 2. Sole sugarcane recorded signifcantly highest single cane weight (2.35) and it was on par with sugarcane + greengram (2.26), sugarcane + blackgram (2.15) and sugarcane + coriander (2.13). Among the intercrops greengram recorded significantly highest single cane weight and it was on par with all intercrops except sesamum (1.60).

**Cane yield (t/ha):**

The data pertaining to cane yield presented in table 2. The three years pooled data indicated that, greengram intercropped with sugarcane recorded highest cane yield (132.7 t/ha) and it was superior over sole sugarcane (124.7), sugarcane + tomato (118.7), sugarcane + clusterbean (115.4) and sugarcane + sesame (76.0). and it was comparable with blackgram (129.5) and coriander (128.7). Lowest was recorded in sesamum (76.0 t/ha). This may be due to shade effect of sesameon sugarcane crop untill 115 days which is crucial for tiller development in sugarcane. These results were in conformity with Rehman *et al*. (2014).

**Land use effciciency (%):**

Data regarding land use effciency presented in table 3. Cultivated land utilization Index (Chuang, 1973) is calculated by summing the products of land area to each crop, multiplied by the actual duration of that crop divided by the total cultivated land times 365 days. Numerically highest land use efficiency was recorded with sugarcane intercropped with clusterbean (126.2) followed by sugarcane intercropped with sesame (122.5). Lowest was recorded in sole sugarcane (91.73).

**Economics:**

Data regarding economics presented in table 3. Numerically less cost of cultivation was recorded in sole sugarcane (Rs. 1,76,917/ha) followed by sugarcane intercropped with coriander (Rs.1,97,738 ha-1). Sugarcane + greengram recorded highest gross returns (Rs. 4,67,001 -ha) and was on par with sugarcane + blackgram (Rs.4,49,450 ha-1). Sugarcane + greengram recorded significantly highest BC ratio (2.28) on par with sugarcane + coriander (2.22) and sugarcane + blackgram (2.18). Lowest BC ratio was recorded with sugarcane intercropped with sesame (1.46). These findings are in agreement with Shilpa *et al.* (2018).

**Conclusion**

In intercropping, each crop must have adequate space to maximize cooperation and minimize competition between them. Thus, four things such as spatial arrangement, density, maturity date of the crops being grown, and plant architecture should be considered. In sugarcane, a variety of intercrops have long been grown, including potatoes, mustard, onions, lentils, tomatoes, garlic, chickpeas, coriander, greengram, blackgram, and more. Additionally, intercropping enhances the farm family's diet's nutritional value, permits more effective weed management, and raises the land equivalent ratio.

**Disclaimer (Artificial intelligence)**

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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**Table 1 Effect of early summer intercrops on tiller count and plant growth characters of sugarcane**

|  |  |
| --- | --- |
| **Treatments** | **Tiller count (‘000/ha)** |
| **90 DAP** | **120 DAP** |
| **2020** | **2021** | **2022** | **Pooled** | **2020** | **2021** | **2022** | **Pooled** |
| T1:Sole Sugarcane | 94.10 | 89.53 | 94.94 | 92.82 | 120.2 | 119.5 | 110.9 | 116.7 |
| T2:Sugarcane + Greengram | 93.32 | 85.27 | 74.33 | 84.20 | 117.3 | 116.6 | 104.3 | 112.4 |
| T3:Sugarcane + Blackgram | 87.15 | 81.33 | 82.22 | 83.52 | 105.6 | 104.7 | 106.0 | 105.1 |
| T4:Sugarcane + Sesame | 65.33 | 53.07 | 48.83 | 55.63 | 70.9 | 69.93 | 81.61 | 73.75 |
| T5: Sugarcane + Tomato | 80.01 | 61.97 | 71.17 | 71.05 | 105.5 | 104.9 | 93.00 | 100.8 |
| T6:Sugarcane + Clusterbean | 76.65 | 70.6 | 83.61 | 76.74 | 113.3 | 113.4 | 94.67 | 107.3 |
| T7:Sugarcane + Coriander | 82.21 | 73.33 | 81.17 | 78.83 | 119.1 | 119.3 | 100.3 | 112.7 |
| SEm (+) | 4.25 | 3.73 | 4.57 | 5.39 | 2.67 | 6.83 | 5.25 | 7.02 |
| CD (p=0.05) | 13.11 | 11.62 | 14.07 | 16.62 | 8.33 | 21.26 | 16.18 | 21.64 |

**Table 2 Effect of early summer intercrops on number of milleable canes, single Cane weight and cane yield of sugarcane**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Number of Milleable Canes (‘000/ha)** | **Single Cane Weight (kg/cane)** | **Cane yield (t/ha)** |
| **2020** | **2021** | **2022** | **Pooled** | **2020** | **2021** | **2022** | **Pooled** | **2020** | **2021** | **2022** | **Pooled** |
| T1:Sole Sugarcane | 102 | 105 | 91.6 | 99.73 | 2.58 | 2.01 | 2.08 | 2.35 | 129.6 | 136.5 | 108.0 | 124.7 |
| T2:Sugarcane + Greengram | 93 | 102 | 98.3 | 97.74 | 2.59 | 1.99 | 1.98 | 2.26 | 126.7 | 164.4 | 107.0 | 132.7 |
| T3:Sugarcane + Blackgram | 87 | 103 | 81.1 | 90.55 | 2.40 | 1.86 | 1.92 | 2.15 | 121.0 | 162.1 | 105.3 | 129.5 |
| T4:Sugarcane + Sesame | 76 | 77 | 66.2 | 73.16 | 1.92 | 1.41 | 1.43 | 1.60 | 84.3 | 72.1 | 71.67 | 76.0 |
| T5: Sugarcane + Tomato | 82 | 93 | 92.7 | 89.29 | 2.12 | 1.74 | 1.47 | 1.90 | 118.0 | 138.2 | 100.0 | 118.7 |
| T6:Sugarcane + Clusterbean | 81 | 85 | 79.2 | 81.76 | 2.01 | 1.66 | 1.73 | 1.94 | 123.3 | 123.5 | 99.33 | 115.4 |
| T7:Sugarcane + Coriander | 97 | 103 | 77.0 | 92.52 | 2.46 | 1.84 | 1.86 | 2.13 | 128.3 | 153.8 | 104.0 | 128.7 |
| SEm (+) | 5.03 | 5.59 |  5.73 |  4.09 | 0.12 | 0.11 | 0.13  |  0.12 | 9.65 | 10.11 | 6.74 | 7.21 |
| CD (p=0.05) | 15.68 | 17.23 | 17.6 | 11.69  | 0.37 | 0.34 | 0.41  |  0.33 | 24.73 | 27.57 | 20.76 | 19.28 |

**Table 3 Effect of early summer intercrops on land utilization efficiency and economics of sugarcane**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Land Utilization Efficiency (%)** | **Gross returns (₹/ha)** | **Cost of cultivation (₹/ha)** | **B:C ratio** |
| **2020** | **2021** | **2022** | **Pooled** |
| T1:Sole Sugarcane | 91.78 | 91.78 | 91.6 | 91.73 | 378791 | 176917 | 2.11 |
| T2:Sugarcane + Greengram | 113.6 | 114.6 | 115.6 | 114.6 | 467001 | 206037 | 2.28 |
| T3:Sugarcane + Blackgram | 115.0 | 115.07 | 116.2 | 115.4 | 449450 | 206383 | 2.18 |
| T4:Sugarcane + Sesame | 121.9 | 120.9 | 123.5 | 122.5 | 294081 | 200612 | 1.46 |
| T5: Sugarcane + Tomato | 116.4 | 115.0 | 120.2 | 117.2 | 419593 | 245305 | 1.71 |
| T6:Sugarcane + Clusterbean | 124.7 | 128.5 | 125.6 | 126.2 | 437072 | 241459 | 1.82 |
| T7:Sugarcane + Coriander | 115.1 | 113.1 | 120.5 | 116.2 | 438590 | 197738 | 2.22 |
| SEm (+) | - | - | - | - | 19052 | - | 0.06 |
| CD (p=0.05) | - | - | - | - | 51506 | - | 0.16 |