**Original Research Article**

**Economic evaluation of alternative crops and cropping systems for sugarcane under Northern Transition Zone of Karnataka**

**ABSTRACT**

A field experiment with an objective of studying “Economic evaluation of alternative crops and cropping systems for sugarcane under Northern Transition Zone of Karnataka” was conducted at Agricultural Research Station, Hukkeri, Belagavi, Karnataka, India during 2018-19 and 2019-20. There were 11 treatments involving different cropping systems *viz.,* soybean - sorghum - ridge gourd (T1), pigeon pea + green gram(1:1) - beans (T2), pigeon pea + soybean(1:1) - cowpea (T3), soybean - wheat - groundnut (T4), groundnut - sorghum - sesame (T5), maize - cabbage - fallow (T6), soybean - wheat - green gram (T7), maize - wheat - sesame (T8), Bt cotton - groundnut (T9), sugarcane + onion (1:2) [T10] and sugarcane (sole) [T11] replicated thrice and laid out in randomized complete block design. The intercropping treatments were in additive series. Considering field crop + vegetable alternative cropping systems for sugarcane, maize-cabbage-fallow system recorded significantly higher net returns (` 2,49,923 ha-1) and B:C ratio (2.54) compared to rest of the cropping systems and sugarcane (sole) (` 1,21,919 ha-1 and 1.97, respectively). Based on alternative cropping systems involving only field crops, significantly higher net returns and B:C ratio were recorded compared to sugarcane (sole), from soybean-wheat-groundnut (` 1,51,651 ha-1 and 2.21), maize-wheat-sesame (` 1,50,231 ha-1 and 2.28), soybean-wheat-green gram (` 1,40,907 ha-1 and 2.29), Bt cotton-groundnut (` 1,33,519 ha-1 and 2.40) and sugarcane + onion (1:2) intercropping (` 1,31,294 ha-1 and 1.52), respectively. As these alternative cropping systems are more productive, can be recommended as viable option to sugarcane monocropping in Northern Transition Zone of Karnataka**.**

**Key words: Alternative crops, sugarcane, Gross returns, Net returns, B:C ratio**

**INTRODUCTION**

Sugarcane (*Saccharum officinarum* L.) is an important commercial crop and grown as a cash crop in the world and India. It occupies a prominent position in the Indian agricultural scenario on account of its wider adoption in different agro-climatic conditions. In the world, sugarcane occupies an area of 26.54 mha with production of 1861 mt and productivity of 70.13 tha-1. In India, the area is 5.61 mha with production of 442.5 m t and productivity of 69.11 tha-1. Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, Bihar, Gujarat, Haryana, Punjab and Andhra Pradesh are the leading sugarcane producing states in India. In Karnataka, sugarcane is cultivated on an area of 6.37 lakh ha with production of 61.15 mt and productivity of 96 tha-1(Hanji *et. al.,*2024). Sugarcane monocropping and sugarcane-fallow are the most predominant systems practiced in Ghataprabha command areas of Karnataka. These systems for long periods with indiscriminate use of fertilizers, irrigation water coupled with unscientific irrigation management have led to many problems *viz.,* soil salinity, alkalinity, water logging, nutrient imbalance, dominance of pest and diseases incidence and increasing cost of cultivation year by year (Sadashivanagowda, 2020).Other constraints experienced in the command area by farmers are, low crop productivity followed by over irrigation to poor water distribution. Untimely release of water from the canal and not providing summer irrigation are other constraints, delay in payments by factories are other problems faced by farmers every year and also small sugarcane growers need flow of income in the cropping season (Sadashivanagowda, 2020).Hence there is need for the development of an alternative crops and cropping systems for sugarcane in the command areas to get higher productivity and profitability through generating income within a short period of time by breaking the sugarcane monoculture. This situation needs crop-diversification options through introduction of cereals, oilseeds, pulses, spices, fodder crops and other remunerative crops for their livelihood security. It was also recognized as an effective strategy for achieving the objectives of food security, nutrition security, income growth, poverty alleviation, employment generation and judicious use of land and water resources, sustainable agricultural development and environmental improvement (Hegde *et al.,* 2003). Thus, diversification of the system through introduction of crops of diverse nature may be a good preposition to break the monotony of the predominant sugarcane systems and to sustain productivity. In this context, this paper examines alternative cropping systems for sugarcane in command areas by integrating different crops for sustaining the productivity and famers’ income throughout the year.

**MATERIAL AND METHODS**

The field experiment was conducted during 2018-20 at Agricultural Research Station, Hukkeri which is situated in the Northern transition zone (Agro-climatic Zone 8) of Karnataka, India. The soil of the experimental site was medium black clay loam having normal pH of 7.81 and EC of 0.72 dSm-1, medium in organic carbon ( 0.53 %), low in available nitrogen (236.74 kg ha-1), medium in available phosphorus (14.79 kg ha-1) and high in available potassium (317.41 kg ha-1). It was laid out in Randomised Complete Block Design and replicated thrice. There were 11 treatments consisting of soybean - sorghum - ridge gourd (T1), pigeon pea + green gram (1:1) - beans (T2), pigeon pea + soybean (1:1) - cowpea (T3), soybean - wheat - groundnut (T4), groundnut - sorghum - sesame (T5), maize - cabbage - fallow (T6), soybean - wheat - green gram (T7), maize - wheat - sesame (T8), Bt cotton - groundnut (T9), sugarcane + onion (1:2) [T10] and sugarcane (sole) [T11]. The intercropping treatments were in additive series. The seed rate, row spacing and other inputs for *kharif* (rainy), *rabi* (post rainy) and summer crops was followed as per the recommended package of practices (RPP) and different crops were sown during respective seasons for both the years. Irrigation was provided regularly for sugarcane and to summer season crops and protective irrigation for *rabi* crops at critical stages. Plant protection and weed management measures were attended and when required. Harvesting was done based on the maturity of individual crops during their respective seasons. Economic parameters of alternative cropping systems worked out by following formula.

Cost of cultivation (Rs.ha-1): The prevailing market price of input materials and labour costs were considered for computing the cost of cultivation and expressed in Rs. per ha

Gross returns(Rs.ha-1): Based on the prevailing market price of main produce (seeds) and by-product at harvest, the gross returns was calculated in Rs. per ha.

Net returns (Rs.ha-1): Deducting the total cost of cultivation from total monetary value of the produce, net returns was calculated.

*i.e.,* Net returns = Gross returns (Rs.ha-1) – Total cost of cultivation (Rs.ha-1)

 Benefit cost ratio (B:C): To know the rate of return per rupee invested, benefit cost ratio (B:C) was worked out using the formula.

 Gross returns (Rs.ha-1)

 B:C =

 Total cost of cultivation (Rs.ha-1)

**Statistical analysis**: The analysis and interpretation of data were carried out using the Fisher’s method of analysis of variance technique as described by Gomez and Gomez (1984).

**RESULTS AND DISCUSSION**

**3.1 Productivity**

The pooled data of two seasons for *kharif* resulted in maize recording significantly higher grain yield (T6, 6123 kg/ha) which was on par with maize (T8, 6012 kg/ha) compared to rest of the crops. The other higher yielding crops were *viz.,* groundnut with higher dry pod yield (T5, 2355 kg/ha) followed by soybean (T4, 2275 kg/ha), soybean (T7, 2267 kg/ha), Bt cotton (T9, 2201 kg/ha) and soybean (T1, 2182 kg/ha) [Table 1].

The pooled data for *rabi* season showed that, cabbage recorded significantly higher head yield (T6, 52111 kg/ha) compared to rest of the crops. Amongst other treatments *viz.,* onion intercropped with sugarcane recorded significantly higher bulb yield (T10, 4626 kg/ha) followed by wheat (T7, 3206 kg/ha), wheat (T4, 3111 kg/ha), wheat (T8, 2948 kg/ha) and sorghum.

During summer (pooled), sugarcane in intercropping system recorded significantly higher cane yield (T10, 113515 kg/ha) and it was on par with sugarcane (sole) (T10, 111008 kg/ha) compared to other treatments. Next in the order, were ridge gourd with higher fruit yield (T1, 6864 kg/ha) followed by beans (T2, 6117 kg/ha), groundnut (T9, 2302 kg/ha), groundnut (T4,2216 kg/ha), cowpea (T3, 1355 kg/ha) and green gram (T7, 951 kg/ha). Sesame recorded the significantly lower seed yield (T5, 688 kg/ha and T8, 673 kg/ha).

 Higher productivity of respective crops was due to genetic characteristics of individual crops *viz.,* faster growth (cereals), slow growth (pulses), nutrient uptake of individual crops, nutrient exhaustiveness (cereals), yield potentiality, different ideotypes, early maturity/duration with high yielding ability, photosynthesis and translocation of photosynthates to reproductive organs *i.e.,* from source of sink. These results are in conformity with the findings of Rao and Rogers (2006), Mukherjee (2010) in rice-cauliflower, Ashutosh *et al.* (2018) in pigeon pea intercropped with black gram, Bhargavi and Behera (2019) in bottle gourd-onion, Bhadre *et al.* (2019) in soybean, Bhat *et al.* (2013) in maize, Biswas (2017) in jute-potato-rice and Sujatha and Babalad (2018) in pigeon pea in intercropping system.

**3.2 Cost of cultivation of alternative crops and cropping system**

During 2018, among the cropping systems, sugarcane + onion (1:2) recorded higher cost of cultivation (T10, ` 2,23,057ha-1) followed by maize-cabbage-fallow system (T6, ` 1,59,098ha-1), soybean-sorghum-ridge gourd (T1, ` 1,30,540ha-1), sugarcane (sole) (T11, ` 1,27,199ha-1), soybean-wheat-groundnut (T4, ` 1,26,364ha-1) and pigeon pea + green gram (1:1)- beans (T2, ` 1,22,903ha-1) compared to the other cropping systems. However, the lower cost of the cultivation was recorded with pigeon pea + soybean (1:1)- cowpea (T3, ` 72,880ha-1) and Bt cotton-groundnut (T9, ` 92,733ha-1) [Table 2].

During 2019, similar trend of 2018 followed. Sugarcane + onion (1:2) system recorded higher cost of cultivation (T10, ` 2,21,307ha-1) followed by maize-cabbage-fallow system (T6, ` 1,58,158ha-1), soybean-sorghum-ridge gourd (T1, ` 1,28,093ha-1), soybean-wheat-groundnut (T4, ` 1,25,714ha-1), sugarcane (sole) (T11, ` 1,25,449ha-1) and pigeon pea + green gram (1:1) - beans (T2, ` 1,24,513ha-1) compared to rest of the cropping systems.

The significantly lower cost of cultivation was recorded with pigeon pea + soybean (1:1) - cowpea (T3, ` 75,247ha-1) and Bt cotton-groundnut (T9, ` 96,882ha-1).

Much seasonal variation for cost of cultivation was observed as season-wise different crops were involved in cropping systems.

**3.3 Gross returns for alternative crops and cropping systems**

The pooled data of two years for total gross returns indicated that, among the cropping systems, maize-cabbage-fallow system recorded significantly higher total gross returns (T6, ` 4,08,551ha-1) compared to rest of the cropping systems and sugarcane (sole) (T11, ` 2,48,243ha-1). However, sugarcane + onion (1:2) (T10, ` 3,53,476ha-1) cropping system was significantly higher compared to rest of the cropping systems. The other superior cropping systems over sugarcane (sole) were soybean-wheat-groundnut (T4, ` 2,77,690ha-1), maize-wheat-sesame (T8, ` 2,67,837ha-1), pigeon pea + green gram (1:1) - beans (T2, ` 2,50,961ha-1) and soybean - wheat - green gram (T7, ` 2,50,472ha-1). The significantly lower total gross returns was recorded with pigeon pea + soybean (1:1) - cowpea (T3, ` 1,95,522ha-1). Seasonal variation was more because of different crops involved and their prevailing market price [Table 3].

The pooled data of *kharif* for gross returns showed that, Bt cotton recorded significantly higher gross returns (T9, ` 1,27,840ha-1) and it was on par with maize (T6, ` 1,20,928ha-1 and T8, 1,18,426ha-1) compared to rest of the crops. The next best crops with higher gross returns were groundnut (T5, ` 96,503ha-1) and soybean (T4, ` 95,649ha-1, T7, ` 95,243ha-1 and T1, ` 91,751ha-1). The significantly lower gross returns was recorded with soybean intercropped with pigeon pea (T3, ` 29,824ha-1).

The *rabi* pooled data for gross returns indicated that, cabbage recorded significantly higher gross returns (T6, ` 2,87,623ha-1) compared to rest of the crops. The next best crops for higher gross returns were onion (T10, ` 96,085ha-1), pigeon pea (T3, ` 93,390ha-1 and T2, ` 90,482ha-1) and wheat (T7, ` 87,950ha-1).The significantly lower gross returns was found with sorghum (T1, ` 56,560ha-1).

During summer (pooled), sugarcane + onion (1:2) recorded significantly higher gross returns (T10, ` 2,53,953ha-1) and it was on par with sugarcane (sole) (T11, ` 2,48,243ha-1) compared to rest of the crops. However, beans was significantly superior (T2, ` 1,16,352ha-1) compared to rest of the crops. The next best crops with higher gross returns were groundnut (T9, ` 1,00,487ha-1 and T4, ` 96,678ha-1), ridge gourd (T1, ` 87,468ha-1), sesame (T5, ` 72,981ha-1), cowpea (T3, ` 72,308ha-1) and sesame (T8, ` 71,288ha-1). The significantly lower gross returns was recorded with green gram (T7, ` 67,277ha-1).

Similar trend was also observed during both the years for seasonal and total gross returns.

 **3.4** **Net returns for alternative crops and cropping systems**

The pooled data for total net returns indicated that, among the cropping systems, maize-cabbage-fallow system recorded significantly higher total net returns (T6, ` 2,49,923ha-1) compared to rest of the cropping systems. The higher net returns realized in these cropping systems was due to higher gross returns, higher productivity of individual crops and higher market price for the produce of the respective crops and seasons. The results are in line with the findings of Mahadevaswamy and Martin (2002) in sugarcane + onion, Mukherjee (2010) in black gram-wheat, Tuti *et al.* (2013) in pigeon pea-lentil, Khadam (2015) in soybean-wheat, Shridhara *et al.* (2017) in cotton-sesame, Mukherjee (2016) in rice-cauliflower, Bhadre *et al.* (2019) in soybean-safflower, Seemantini (2017) in sugarcane + onion (1:2) and Nooli (2019) in sugarcane. The next best cropping systems for higher total net returns were soybean-wheat-groundnut (T4, ` 1,51,651ha-1), maize-wheat-sesame (T8, ` 1,50,231ha-1), soybean-wheat-green gram (T7, ` 1,40,907ha-1), Bt cotton-groundnut (T9, ` 1,33,519ha-1) and sugarcane + onion (1:2) (T10, ` 1,31,294ha-1). However, the sugarcane (sole) was on par with groundnut-sorghum-sesame. The soybean-sorghum-ridge gourd cropping system (T1, ` 1,06,462ha-1) recorded significantly lower net returns and was on par with T3, T11 and T2[Table 4 and Figure 1].

Season-wise variation was more because of different crops involved and their prevailing market price.

*kharif* season data (pooled) indicated that, Bt cotton recorded significantly higher net returns (T9, ` 78,235ha-1) and it was on par with maize (T6, ` 71,213ha-1 and T8, ` 69,105ha-1) compared to rest of the crops. The next best crops for higher net returns were soybean (T4, ` 53,684ha-1 and T7, ` 53,066ha-1), groundnut (T5, ` 52,520ha-1) and soybean (T1, ` 49,833ha-1).

Net returns for *rabi* season (pooled) indicated that, cabbage recorded significantly higher net returns (T6, ` 1,78,710ha-1) compared to rest of the crops. The other crops with higher net returns were pigeon pea (T3, ` 57,125ha-1 and T2, ` 54,177ha-1) and wheat (T7, ` 49,182ha-1 and T4, ` 46,572ha-1).

For summer pooled data sugarcane in intercropping recorded significantly higher net returns (T10, ` 1,27,629ha-1) and it was on par with sugarcane (sole) (T11, ` 1,21,919ha-1) compared to rest of the crops. The next in the order for higher net returns were groundnut (T9, ` 55,284ha-1 and T4, ` 51,395ha-1), cowpea (T3, ` 46,090ha-1) and sesame (T5, ` 43,416ha-1 and T8, ` 41,723ha-1).

The net returns for respective season-wise and for total during individual years also followed the similar trend.

**3.5 Benefit cost ratio for alternative crops and cropping systems**

In general, sugarcane (sole) recorded significantly lower mean benefit cost ratio (B:C) compared to rest of the cropping systems and crops except with T1 (soybean-sorghum-ridge gourd) [Table 5 and Figure 1].

The mean (pooled) benefit cost ratio indicated that, among the cropping systems, pigeon pea + green gram (1:1)-beans recorded significantly higher B:C ratio (T2, 3.14) compared to rest of the cropping systems.

**CONCLUSION**

It can be concluded that, considering field crop + vegetable alternative cropping systems for sugarcane, maize-cabbage-fallow system recorded significantly higher net returns (` 2,49,923 ha-1) and B:C ratio (2.54) compared to rest of the cropping systems and sugarcane (sole) (` 1,21,919 ha-1 and 1.97, respectively). Based on alternative cropping systems involving only field crops, significantly higher net returns and B:C ratio were recorded compared to sugarcane (sole), from soybean-wheat-groundnut (` 1,51,651 ha-1 and 2.21), maize-wheat-sesame (` 1,50,231 ha-1 and 2.28), soybean-wheat-green gram (` 1,40,907 ha-1 and 2.29), Bt cotton-groundnut (` 1,33,519 ha-1 and 2.40) and sugarcane + onion (1:2) intercropping (` 1,31,294 ha-1 and 1.52), respectively. As these alternative cropping systems are more productive, can be recommended as viable option to sugarcane monocropping in Northern Transition Zone of Karnataka

**REFERENCES**

Ashutosh, B., Singh, V.K., Shambhoo Prasad, Naveen Rawat and Hariom Shah, 2018. Productivity and profitability of pigeon pea (*Cajanus cajan*) in pigeon pea based cropping system under different integrated nutrient management practices in Tarai region of Uttarakhand. International Journal of Chemical Studies, 6(2), 3488-3492.

Bhadre, C. K., Narkhede, W. N. and Gokhale, D. N., 2019, Growth, yield and economics of soybean-safflower cropping sequence as influenced by different land configuration and nutrient management. *J. Pharmacogn. Phytochem.,*  8 (1): 169-173.

Bhadre, C.K., Narkhede, W.N. and Gokhale, D.N., 2019. Growth, yield and economics of soybean-safflower cropping sequence as influenced by different land configuration and nutrient management. Journal of Pharmacognocy and Phytochemistry, 8(1), 169-173.

Bhargavi, B. and Behera, U. K., 2019. System productivity and energetics of high value crops embedded diversified cropping systems. International Journal of Current Microbiology and Applied Science, 8 (1), 1895-1905.

Bhat, R. A., Latief Ahmad and Wani, G. A., 2013. Growth, yield and economics of maize as affected by cropping sequences, rates and frequency of farm yard manure (FYM). *African Journal of Agriculture Research,* 8(27), 3632-3638.

Biswas, B., 2017. Cropping system analysis for agricultural sustainability – productivity, economy, ecology and energy use efficiency. *Journal of Experimental Biology and Agricultural Sciences,* 5(3):294-301.

Gomez, K. M. and Gomez, A. A., 1984, *Statistical Procedures for Agricultural Research,* Edition 2, John Wiley, New York.

Hanji,S.S., Shashi Kiran, A.S., Gaddi, G.M. and Somashekar,K.S., 2024, Growth dynamics of sugarcane in North Karnataka, India. Journal of Scientific Research and Reports 30(7), 869-876.

Hegde,D.M., Tiwar,P.S. AND Rai,M.,2003, Crop diversification in Indian Agriculture. *Agricultural situation in India,* 60(5):255-272.

Khadam, N. A., 2015, Economics of soybean-wheat and soybean-gram sequence cropping systems in Parbhani district. *M. Sc. (Agri.) Thesis,* Vasanthrao Naik Marathwad Krishi Vidyapeeth, Maharastra (India).

Mahadevaswamy, M. and Martin, G. J., 2002, Production and potential of wide row sugarcane intercropped with aggregatum drill sown onion (*Allium cepa*) under different row ratios, fertilizer levels and population densities. *Indian J. Agron.,* 47 (3): 361-366.

Mukherjee, D., 2016, Evaluation of Different Crop Sequence Production Potential, Economics and Nutrient Balance under New Alluvial Situation of North Eastern Plain Zone. *Int. J. Agric. Hort.,* 1 (1): 1-5.

Nooli, S. S., 2019, Organic nutrient management on yield and quality of sugarcane and jaggery. *Ph. D Thesis,* Univ. Agric. Sci., Dharwad, Karnataka (India).

Rao, N. H. and Rogers, P. P., 2006. Assessment of agricultural sustainability. Current Science , 91 (4),439-446.

Sadashivanagowda, S.N.O., 2020, Evaluation of alternative crops and cropping systems for sugarcane in Northern Transition Zone of Karnataka**.** *Ph. D. Thesis*, Univ. Agric. Sci., Dharwad, Karnataka.

Seemantini, N., 2017, Performance of sugarcane based intercropping systems under wide row spacings. *Ph. D. Thesis*, Univ. Agric. Sci., Dharwad, Karnataka.

Sridhar, B. N., Basavanneppa, M. A., Sawargaonkar, G. L., Biradar, D. P., Biradar, S. A. and Tevari, P., 2017, Diversification of rice-rice (*Oryza sativa* L.) cropping systems for productivity, profitability and resource use efficiency in Tungabhadra Project Command area. *Bull. Env. Pharmacol. Life Sci.,* 6 (3): 108-114.

Sujatha, H.T. and Babalad, H.B., 2018. System productivity and economics of transplanted and direct sown pigeon pea at different cropping geometry and intercropping systems. International Journal of Pure and Applied Bioscience,6 (1), 694-700.

Tuti, M. D., Mahanta, D., Bhattacharya, R., Pandey, B. M., Bisht, J. K. and Bhatt, J. C., 2013, Productivity, economics and energetics of pigeonpea (*Cajanus cajan*) based cropping systems in mid-hills of north–west Himalaya. *Indian J. Agron.,* 58 (3): 303-308.

**Table 1: Productivity of alternative crops and cropping systems for sugarcane (pooled)**

|  |  |
| --- | --- |
| **Treatment** | **Productivity (kg ha- 1)** |
| ***Kharif*** | ***Rabi*** | **Summer** |
| T1 : Soybean - sorghum - ridge gourd | 2182 | 1676 | 6864 |
| T2 : Pigeon pea + green gram\* (1:1) - beans  | 596 | 1460 | 6117 |
| T3 : Pigeon pea + soybean\* (1:1) - cowpea | 698 | 1512 | 1355 |
| T4 : Soybean - wheat - groundnut | 2275 | 3111 | 2216 |
| T5 : Groundnut - sorghum - sesame | 2355 | 1799 | 688 |
| T6 : Maize - cabbage - fallow | 6123 | 52111 | - - - - |
| T7 : Soybean - wheat - green gram | 2267 | 3206 | 951 |
| T8 : Maize - wheat - sesame | 6012 | 2948 | 673 |
| T9 : Bt cotton - groundnut |  2201 | 2302 |
| T10 : Sugarcane + onion\* (1:2)  |  | 4626 | 113515 |
| T11 : Sugarcane (sole) |  111008 |
| **S.Em. ±** | 151.95 | 228.53 | 1316.40 |
| **LSD (p = 0.05)** | 455.54 | 685.14 | 3911.23 |

**Note:** Bt cotton, pigeon pea and sugarcane are considered as *kharif, rabi* and summer crops, respectively, \*Additive series intercropping systems

**Table 2: Cost of cultivation of alternative crops and cropping system for sugarcane**

|  |  |
| --- | --- |
| **Treatment** | **Cost of cultivation (Rs. ha - 1)** |
| **2018** | **2019** |
| ***Kharif*** | ***Rabi*** | **Summer** | **Total** | ***Kharif*** | ***Rabi*** | **Summer** | **Total** |
| T1 : Soybean - sorghum - ridge gourd | 41911 | 36183 | 52446 | **130540** | 41925 | 34822 | 51346 | **128093** |
| T2 : Pigeon pea + green gram (1:1) - beans  | 8120 | 36355 | 78428 | **122903** | 8080 | 36255 | 80178 | **124513** |
| T3 : Pigeon pea + soybean (1:1) - cowpea | 11407 | 36355 | 25118 | **72880** | 11754 | 36175 | 27318 | **75247** |
| T4 : Soybean - wheat - groundnut | 41965 | 39391 | 45008 | **126364** | 41965 | 38191 | 45558 | **125714** |
| T5 : Groundnut - sorghum - sesame | 43873 | 35955 | 29440 | **109268** | 44093 | 34582 | 29690 | **108365** |
| T6 : Maize - cabbage - fallow | 49685 | 109413 | - - - | **159098** | 49745 | 108413 | - - - | **158158** |
| T7 : Soybean - wheat - green gram | 42149 | 39324 | 28245 | **109718** | 42205 | 38218 | 28990 | **109413** |
| T8 : Maize - wheat - sesame | 49443 | 39306 | 29440 | **118189** | 49200 | 38133 | 29690 | **117023** |
| T9 : Bt cotton - groundnut | 47925 |  | 44808 | **92733** | 51284 |  | 45598 | **96882** |
| T10 : Sugarcane + onion (1:2)  |  | 95858 | 127199 | **223057** |  | 95858 | 125449 | **221307** |
| T11 : Sugarcane (sole) |  |  | 127199 | **127199** |  |  | 125449 | **125449** |

**Table 3: Gross returns for alternative crops and cropping systems for sugarcane**

|  |  |
| --- | --- |
| **Treatment** | **Gross returns (2000px-Indian_Rupee_symbol ha - 1)** |
| **2018** | **2019** | **Pooled** |
| ***Kharif*** | ***Rabi*** | **Summer** | **Total** | ***Kharif*** | ***Rabi*** | **Summer** | **Total** | ***Kharif*** | ***Rabi*** | **Summer** | **Total** |
| T1 : Soybean - sorghum - ridge gourd | 96705 | 52093 | 91750 | **240548** | 86798 | 61026 | 83185 | **231009** | 91751 | 56560 | 87468 | **235778** |
| T2 : Pigeon pea + green gram (1:1) - beans  | 46708 | 87299 | 107889 | **241897** | 41547 | 93664 | 124815 | **260025** | 44128 | 90482 | 116352 | **250961** |
| T3 : Pigeon pea + soybean (1:1) - cowpea | 32475 | 90654 | 71218 | **194347** | 27173 | 96126 | 73398 | **196697** | 29824 | 93390 | 72308 | **195522** |
| T4 : Soybean - wheat - groundnut | 100383 | 82922 | 87328 | **270633** | 90916 | 87804 | 106028 | **284748** | 95649 | 85363 | 96678 | **277690** |
| T5 : Groundnut - sorghum - sesame | 99694 | 54407 | 78815 | **232916** | 93312 | 60654 | 67148 | **221114** | 96503 | 57531 | 72981 | **227015** |
| T6 : Maize - cabbage - fallow | 130863 | 250432 | - - - | **381295** | 110993 | 324815 | - - - | **435807** | 120928 | 287623 | - - - | **408551** |
| T7 : Soybean - wheat - green gram | 100420 | 86333 | 62488 | **249241** | 90065 | 89572 | 72067 | **251704** | 95243 | 87953 | 67277 | **250472** |
| T8 : Maize - wheat - sesame | 128120 | 75914 | 76032 | **280066** | 108732 | 80333 | 66543 | **255609** | 118426 | 78123 | 71288 | **267837** |
| T9 : Bt cotton - groundnut | 138148 |  | 91225 | **229373** | 117531 |  | 109750 | **227281** | 127840 |  | 100487 | **228327** |
| T10 : Sugarcane + onion (1:2)  |  | 91654 | 238679 | **330333** |  | 107390 | 269228 | **376618** |  | 96085 | 253953 | **353476** |
| T11 : Sugarcane (sole) |  |  | 234212 | **234212** |  |  | 262273 | **262273** |  |  | 248243 | **248243** |
| **S.Em. ±** | 6832 | 7256 | 5705 | **11141** | 6327 | 5989 | 6467 | **8694** | 4845 | 3461 | 4887 | **8067** |
| **LSD (p = 0.05)** | 20484 | 21755 | 16952 | **32866** | 18969 | 17956 | 19216 | **25648** | 14525 | 10378 | 14521 | **23798** |

**Market price (Rs. kg - 1) : Soybean :** 41.0 and 39.0, **Green gram :** 69.75 and 70.50, **Groundnut** : 40.0 and 45.0**, Maize :** 20.0 and 17.0, **Bt cotton :** 60 and 56, **Pigeon pea :** 56 and 58, **Sorghum :** 30 and 34**, Wheat :** 26 and 27**, Cabbage** : 5 and 6**, Onion :** 20 and 23, **Ridge gourd :** 13.5 and 12, **Beans :** 18 and 20, **Cowpea :**47.25 and 50. **Sesame :** 114 and **Sugarcane :** Rs.2000 and 2500 t - 1 for 2018 and 2019, respectively

**Note :** For vegetables, field crops’ produce and cane, price were considered based on wholesale, APMC and sugar factory, respectively

**Table 4: Net returns for alternative crops and cropping systems for sugarcane**

|  |  |
| --- | --- |
| **Treatment** | **Net returns (2000px-Indian_Rupee_symbol ha - 1)** |
| **2018** | **2019** | **Pooled** |
| ***Kharif*** | ***Rabi*** | **Summer** | **Total** | ***Kharif*** | ***Rabi*** | **Summer** | **Total** | ***Kharif*** | ***Rabi*** | **Summer** | **Total** |
| T1 : Soybean - sorghum - ridge gourd | 54794 | 15910 | 39304 | **110008** | 44873 | 26204 | 31839 | **102916** | 49833 | 21057 | 35572 | **106462** |
| T2 : Pigeon pea + green gram (1:1) - beans  | 38588 | 50944 | 29461 | **118994** | 33467 | 57409 | 44637 | **135512** | 36028 | 54177 | 37049 | **127253** |
| T3 : Pigeon pea + soybean (1:1) - cowpea | 21068 | 54299 | 46100 | **121467** | 15419 | 59951 | 46080 | **121450** | 18244 | 57125 | 46090 | **121459** |
| T4 : Soybean - wheat - groundnut | 58418 | 43531 | 42320 | **144269** | 48951 | 49613 | 60470 | **159034** | 53684 | 46572 | 51395 | **151651** |
| T5 : Groundnut - sorghum - sesame | 55821 | 18452 | 49375 | **123648** | 49219 | 26072 | 37458 | **112749** | 52520 | 22262 | 43416 | **118199** |
| T6 : Maize - cabbage - fallow | 81178 | 141019 | - - - | **222197** | 61248 | 216402 | - - - | **277649** | 71213 | 178710 | - - - | **249923** |
| T7 : Soybean - wheat - green gram | 58271 | 47009 | 34243 | **139523** | 47860 | 51354 | 43077 | **142291** | 53066 | 49182 | 38660 | **140907** |
| T8 : Maize - wheat - sesame | 78677 | 36608 | 46592 | **161877** | 59532 | 42200 | 36853 | **138586** | 69105 | 39404 | 41723 | **150231** |
| T9 : Bt cotton - groundnut | 90223 |  | 46417 | **136640** | 66247 |  | 64152 | **130399** | 78235 |  | 55284 | **133519** |
| T10 : Sugarcane + onion (1:2)  |  | - 4204 | 111480 | **107276** |  | 11532 | 143779 | **155311** |  | 3664 | 127629 | **131294** |
| T11 : Sugarcane (sole) |  |  | 107013 | **107013** |  |  | 136824 | **136824** |  |  | 121919 | **121919** |
| **S.Em. ±** | 6832. | 7256 | 5706 | 11142 | 6327 | 5990 | 6468 | 8695 | 4845 | 3471 | 5165 | 8068 |
| **LSD (p = 0.05)** | 20484 | 21755 | 16953 | 32867 | 18970 | 17957 | 19217 | 25648 | 14525 | 10406 | 15485 | 23799 |

**Table 5: Benefit cost ratio for alternative crops and cropping systems for sugarcane**

|  |  |
| --- | --- |
| **Treatment** | **B : C ratio** |
| **2018** | **2019** | **Pooled** |
| ***Kharif*** | ***Rabi*** | **Summer** | **Mean** | ***Kharif*** | ***Rabi*** | **Summer** | **Mean** | ***Kharif*** | ***Rabi*** | **Summer** | **Mean** |
| T1 : Soybean - sorghum – ridge gourd | 2.31 | 1.44 | 1.75 | **1.75** | 2.07 | 1.75 | 1.62 | **1.62** | 2.19 | 1.60 | 1.68 | **1.68** |
| T2 : Pigeon pea + green gram (1:1) - beans  | 5.75 | 2.40 | 1.38 | **3.18** | 5.14 | 2.58 | 1.56 | **3.09** | 5.45 | 2.49 | 1.47 | **3.14** |
| T3 : Pigeon pea + soybean (1:1) - cowpea | 2.85 | 2.49 | 2.84 | **2.73** | 2.31 | 2.66 | 2.69 | **2.55** | 2.58 | 2.58 | 2.76 | **2.64** |
| T4 : Soybean - wheat - groundnut | 2.39 | 2.11 | 1.94 | **2.15** | 2.17 | 2.30 | 2.33 | **2.26** | 2.28 | 2.20 | 2.13 | **2.21** |
| T5 : Groundnut - sorghum - sesame | 2.27 | 1.51 | 2.68 | **2.15** | 2.12 | 1.75 | 2.26 | **2.04** | 2.19 | 1.63 | 2.47 | **2.10** |
| T6 : Maize - cabbage - fallow | 2.63 | 2.29 | - - | **2.46** | 2.23 | 3.00 | - - | **2.61** | 2.43 | 2.64 | - - | **2.54** |
| T7 : Soybean - wheat - green gram | 2.38 | 2.20 | 2.21 | **2.26** | 2.13 | 2.34 | 2.49 | **2.32** | 2.26 | 2.27 | 2.35 | **2.29** |
| T8 : Maize - wheat - sesame | 2.59 | 1.93 | 2.58 | **2.37** | 2.21 | 2.11 | 2.24 | **2.19** | 2.40 | 2.02 | 2.41 | **2.28** |
| T9 : Bt cotton - groundnut | 2.88 |  | 2.04 | **2.46** | 2.29 |  | 2.41 | **2.35** | 2.59 |  | 2.22 | **2.40** |
| T10 : Sugarcane + onion (1:2)  |  | 0.88 | 1.88 | **1.42** |  | 1.12 | 2.15 | **1.63** |  | 1.00 | 2.01 | **1.52** |
| T11 : Sugarcane (sole) |  |  | 1.84 | **1.84** |  |  | 2.09 | **2.09** |  |  | 1.97 | **1.97** |
| **S.Em. ±** | 0.20 | 0.19 | 0.15 | 0.09 | 0.26 | 0.12 | 0.16 | 0.10 | 0.13 | 0.08 | 0.13 | 0.08 |
| **LSD (p = 0.05)** | 0.59 | 0.56 | 0.46 | 0.28 | 0.79 | 0.36 | 0.46 | 0.29 | 0.40 | 0.25 | 0.38 | 0.24 |

 Figure 1: Economic parameters **for alternative crops and cropping systems for sugarcane (pooled 2018 and 2019)**