



E-ISSN: 2278-4136

P-ISSN: 2349-8234

[www.phytojournal.com](http://www.phytojournal.com)

JPP 2020; 9(5): 2992-2995

Received: 04-06-2020

Accepted: 08-07-2020

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## A review on intercropping effects on growth and yield of sugarcane

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DOI: <https://doi.org/10.22271/phyto.2020.v9.i5ap.12794>

**Abstract**

Intercropping is a practice in which two or more crops are grown in the same place and time. It is an ancient and commonly practiced method which usually aims to meet the crop demands more efficiently by facilitating proper utilization of the available resources. Intercropping is capable of giving greater yield on a given piece of land. Sugarcane can be selected as an important intercrop as it takes about 90-120 days for full canopy development. It is intercropped with short duration crops during its early stages. Sugarcane + soybean cropping system is more profitable than cultivation of sole sugarcane. Selection of short duration intercrop, their minimum shading effect on sugarcane and no overlapping of peak nutrient demand of sugarcane with intercrop are key considerations for successful intercropping of sugarcane. Again the intercropping of soybean with sugarcane gave the highest possible values or profit only when 100% sugarcane + 40% soybean in one row. Paired row trench planting sugarcane with sole or intercropped with garlic gives highest cane yield. Therefore, sugarcane is considered as the most suitable crop to be intercropped with other crops to attain better yield and higher economic returns.

**Keywords:** Economic returns, intercropping, soil health, sugarcane, land use efficiency, yield

**1. Introduction**

Due to a rapid increase in the global population, the demand for food is also increasing. Several strategies have been followed around the world to improve land use efficiency [Dhaliwal, 2018] <sup>[4]</sup>. Intercropping can be a viable option to boost crop productivity in farming systems. It is an efficient and eco-friendly method that results in enhanced production. Intercropping ensures best utilization of natural assets and harmonizes the effect of two or more crops grown simultaneously on same unit of land; thus, it is an excellent option in the development of sustainable food production systems [Nadeem *et al.*, 2020] <sup>[12]</sup>. Intercropping is an important aspect to combat the crop failure in rainfed agriculture under the situation of climate change and helps in improving productivity and profitability through efficient utilization of natural resources [Thimmegowda *et al.*, 2016] <sup>[21]</sup>. This system gives spatial and temporal crop intensification of both time and space. Apart from its advantages like diversification, labour distribution, maintenance of soil fertility, suppression of weeds; two major advantages of intercropping are: higher productivity and greater stability through utilization of solar energy, moisture and nutrients [Kapse, 2017] <sup>[2]</sup>. In addition to high productivity of the intercropping system, selection of suitable intercrops also assure greater importance in minimizing the adverse effects on cane yield by utilizing the inter row space thereby reducing the weed infestation [Singh and Uppal, 2015] <sup>[18]</sup>. Intercropping sugarcane with short duration crops enables the small and marginal farmers to get more economic returns on account of better utilization of land, labour, nutrients and irrigation water [Singh and Uppal, 2017] <sup>[20]</sup>. Intercropping can help in meeting the goals of sustainable agricultural production in India.

**2. Intercropping**

Intercropping is the practice of cultivating two or more crops in an available space and therefore is, also called multiple cropping system. The crops are planted in an arrangement that results minimum competition among crops for resources. Though an ancient practice, intercropping is still widespread in most of the developing world [Sam and Ghannay, 2018] <sup>[16]</sup>. Intercropping can be defined as a multiple cropping system in which two or more crops are planted in a field during a growing season. Intercropping is a way to increase diversity in an agricultural ecosystem. It helps in restoring ecological balance, better utilization of resources, increases in the quantity and quality of products and reduction in damage by pests, diseases and weeds ultimately helps in increasing the crop yield. Pest and disease damage in intercropping is less than pure cropping, because pest or pathogen is attracted by the second crop

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species and thus cause less damage to main crop. Also weeds remain in control, in intercropping. Soil fertility increases by using plants of leguminosae family in intercropping, due to the increased biological nitrogen fixation [Mousavi, 2011] <sup>[11]</sup>. In the intercropping, two or more crops are planted together in one place, during their growing season or at least in a timeframe. Therefore it is possible that the plants are different in terms of planting time, and a plant is planted after the first plant [Mazaheri *et al.*, 2006] <sup>[9]</sup>. Solar radiation is a major resource determining growth and yield of crops in intercropping, particularly when other resources like water and nutrients are not severely limiting the crop growth. During growth and development, plants intercept and absorb growth factors like light, energy, water and nutrients and use them to produce biomass. Since these growth factors are distributed variously in space and time, crop complementary and supplementary relations determine the magnitude of intercrop [Ponnaiyan and Tayade, 2015] <sup>[18]</sup>.

### 3. Types of Intercropping

#### 3.1 Mixed Intercropping

Mixed Intercropping is the practice of growing two or more crop species together at the same time in a field without using any particular spatial configuration [Finley *et al.*, 2018] <sup>[5]</sup>. In this method seeds of both the crops are sown by broadcast or dibbling method without any row arrangement. It is easy to do but makes weeding, fertilization and harvesting difficult. Individual plants may compete with each other because they are too close together [Sam and Ghannay, 2018] <sup>[16]</sup>. This type of cropping can be suitable for grass-legume intercropping in pastures [Mousavi, 2011] <sup>[11]</sup>.

#### 3.2 Row Intercropping

Row intercropping system, involves two or more crops grown in the same field simultaneously with one or more of the crops grown in a distinct row arrangement. [Mousavi, 2011] <sup>[11]</sup>. The rows make weeding and harvesting easier than with mixed intercropping [Sam and Ghannay, 2018] <sup>[16]</sup>.

#### 3.3 Strip Intercropping

In strip intercropping system, two or more crops are grown simultaneously in wide strips. To permit the independent cultivation of crops and to letting them to interact ergonomically the spacing should be done properly. [Sam and Ghannay, 2018] <sup>[16]</sup>. Strip intercropping is the practice of growing two or more crop species in separate, but adjacent, rows at the same time [Finley *et al.*, 2018] <sup>[5]</sup>.

#### 3.4 Relay Intercropping

In relay intercropping system, two or more crops are grown simultaneously during the part of their life cycle. When the first crop reaches its reproductive stage or when it is close to maturity, the second crops should be planted immediately but before the harvesting of first crop. This helps to avoid competition between the main crop and the intercrop. It also uses the field for a longer time, since the second crop (the intercrop) usually continues to grow after the main crop is harvested [Sam and Ghannay, 2018] <sup>[16]</sup>. Relay intercropping involves the staggered planting of two or more crops together in a way whereby only parts of their life cycles overlap [Finley *et al.*, 2018] <sup>[5]</sup>.

### 4. Advantages of Intercropping in Sugarcane

Sugarcane crop plays a crucial role in Indian economy since it provides raw material to the second largest agro-based

industry after cotton. It is estimated that by 2030, India will require to produce more than 520 million tonnes of cane with average recovery of 10.75 per cent [Khippal *et al.*, 2016] <sup>[8]</sup>. Intercropping of economically benefiting short duration crops with sugarcane would help to sustain sugarcane cultivation by efficiently utilizing the present limited land resources and helps in providing interim return to farmers.

Sugarcane is one among the important cash crops of our country. It takes about 90-120 days for its full canopy development as it is a long duration crop. When planted in wide row spacing of 150 cm, it allows room for growing intercrops during the early stage. Small and marginal sugarcane growers take it as an opportunity and grow various benefiting short duration crops such as cereals, vegetable, pulses etc. to obtain interim return instead of waiting to get return from sole sugarcane crop [Ponnaiyan and Tayade, 2015] <sup>[13]</sup>. Intercropping has been known as tremendous practice to increase stripped cane yield, maximum net returns, and better resources utilization and fulfil the demand of diversified farms. The gross monetary returns have been recognized the highest from intercropping cane with potato and lowest from pure cane [Finley *et al.*, 2018] <sup>[5]</sup>.

The conventional methods of planting cane do not permit the intercrops to grow well due to shading and competition effect. The popularity of intercropping systems on small growers in the developing countries and the demand for more food has required intensive research on intercropping [Rehman *et al.*, 2014] <sup>[15]</sup>. Intercropping can be exploited as a tool to promote autumn planting which gives 15-20% higher cane yield with a sugar recovery of 0.5 units more than spring planted sugarcane. Autumn-planted sugarcane occupies land for more than one year and hence the farmers have no chance to take another crop in both Rabi and Kharif seasons. The only way to harvest another crop during this period is to grow intercrops. Moreover, autumn sugarcane is very suitable for intercropping because of slow growth rate during the winter and early spring because of prevailing low temperature [Singh *et al.*, 2016] <sup>[19]</sup>.

Intercropping patterns of soybean with sugar cane significantly affect different characters of sugar cane. 100% sugar cane + 40% soybean in one row (2 plants hill-1) gave highest yield values [Morsey *et al.*, 2016] <sup>[19]</sup>. Cane Equivalent Yield (CEY) was higher in sugarcane + soybean intercropping system (132.0 t/ha) followed by sugarcane + green gram (119.4 t/ha). In comparison to sole sugarcane crop, sugarcane + sunhemp gave higher Land Equivalent Ratio of 1.39 followed by green gram (1.37) and soybean (1.21) [Ponnaiyan and Tayade, 2018] <sup>[14]</sup>. Sunhemp is recommended as sugarcane intercrop to achieve highest yield levels. Cultivation of green manure with sugarcane as an intercrop increase millable cane and cane yield sometimes promoting better production compared to chemical fertilizers alone [Islam, 2017] <sup>[6]</sup>. On the basis of various research findings it has been suggested that potato, garlic, french bean, and pea with autumn cane and moong, urd with spring cane could be profitable as compared to sugarcane planted alone in both the seasons. Wheat, maize, barley and radish with autumn cane and sunflower soybean and cotton with spring sugarcane exerted detrimental effect on cane yield [Yadav and Yadav, 2017] <sup>[22]</sup>.

Morsey *et al.*, (2017) <sup>[10]</sup> studied effect of intercropping soybean with sugar cane under different doses of N fertilizer. The intercropping patterns of soybean as 100% sugarcane+30% soybean in one row, 100% sugarcane + 30% soybean in two rows, 100% sugarcane + 40% soybean in one

row, 100% sugarcane + 40% soybean in two rows, pure stand of sugar cane and soybean were distributed in sub-plots. The intercropping patterns of soybean and sugar cane had significant effect on stalk height, stalk weight and can yield/ha in both seasons. Insignificant effect was recorded on number of internodes/stalk in both seasons. Intercropping pattern of 100% sugar cane+ 40% soybean in one row gave the highest values of stalk height and cane yield /ha. In general, higher cane yield/ha was observed from intercropping pattern of 100% sugar cane with 40% soybean compared with pure stand of soybean. Soybean in intercropping increases productivity per unit area of land and enables efficient utilization nutrients and improves soil fertility and field ecological conditions. Therefore, it can be concluded that in the short term, most straightforward approach is to try new combinations of crops to exploit beneficial mechanism that have already been identified, for example new combination of cereals and legumes [Brooker *et al.*, 2014] [2].

Another field experiment was conducted on sugarcane and garlic based inter-cropping systems during autumn season by Singh *et al.*, (2016) [19]. Sugarcane was planted by conventional flat method at 90 cm row spacing and paired row trench planting (90:30 cm). Two and three rows of garlic as an intercrop were planted in sugarcane and were compared with their sole crops. Paired row trench planting sugarcane either sole or intercropped with garlic, recorded higher cane equivalent yield and economic returns than sugarcane planted in furrows on flat beds. Inter-cropping system of two and three rows of garlic with autumn sugarcane recorded similar cane yield. Study indicated that the paired row trench planting sugarcane either sole or intercropped with garlic, recorded higher cane yield (86.4 t/ha, 85.8t/ha, 87.5 t/ha) than sugarcane planted in furrows on flat beds. Intercropping system of two and three rows of garlic with autumn sugarcane recorded similar cane yield of 85.8 t/ha and 87.5 t/ha respectively, than sole sugarcane under both the planting methods. Three rows of garlic recorded higher economic returns than two rows. Thus, autumn planted sugarcane intercropped with three rows of garlic for enhancing land productivity, harnessing crop associability and increasing economic profitability of sugarcane based production system [Singh *et al.*, 2016] [19].

### 5. Socio-economic benefits of sugarcane intercropping

Sugarcane cultivation is profitable but production under with intercropping is more profitable than without intercropping. The different cost variables also have a significant impact on sugarcane production for both with intercropping and without intercropping farm management practices. Sugarcane production can possibly be increased to a great extend and can play a crucial role in the national economy [Ahmed, 2018] [1]. Nadeem *et al.*, (2020) [12] concluded that 120 cm trench planting pattern of sugarcane along with lentil intercropping outperformed in improving the LER and gave maximum economic return as compared to other intercropping patterns and sole planting of sugarcane. Maximum net returns was obtained in Sugarcane + Potato than other intercrops and sole sugarcane while maximum benefit cost ratio was noted in sole sugarcane. Based on economics, it is recommended that resource poor farmers grow only sole sugarcane while resource rich farmers prefer to grow sugarcane + potato due to high returns [Rehman *et al.*, 2013]. In areas where there is a problem of poor germination in pit-planting 21 pre-

germinated cane settling/pit can be transplanted to ensure optimum planting density [Chand *et al.*, 2011] [3].

### 6. Current Status and Future Aspects of Intercropping in Sugarcane

Major considerations for intercropping are the contrasting maturities, growth rhythm, height and rooting pattern, variable insect-pest and disease associated with component crops, so that these complement each other rather than compete for the resources and guard against weather adversities [Singh *et al.*, 2009] [17]. Under rainfed conditions where chances of crop failures are greater, an intercropping is more stable and dependable than growing a sole crop. The major base crops available for intercropping are cereals, oilseeds, cash crops such as cotton (*Gossypium* sp.) and food/fodder legumes. Sugarcane which is traditionally grown in single cropping system can be grown more intensively by opting to its intercropping. The general row spacing followed in sugarcane is 90cm or more. The vacant spaces in between the rows gets quickly covered by weeds, which in turn can compete with the main crop for the uptake of essential nutrients in the later stages. Hence planting any short duration crop in between the vacant spaces is advantageous and helps in cutting down of cost of cultivation of main crop with a deduction on the expenditure on weed control. Now a days due to the loss of one cropping system, the practice of green manuring in sugarcane based intercropping system has been reduced. This condition has resulted in planting green manuring crops in the inter-row spaces of the sugarcane crop. About 13% of an increase in the cane yield has been observed during the first ratoon. This is usually due to the residual effects of sesbania intercropped green manure crop without adversely affecting the plant cane as indicated by the findings of IISR Lucknow. Intercropping spring planted sugarcane with legume crops such as cowpea and green gram has a significant carry over effect [Ahmed, 2018] [1].

### 7. Conclusion

Intercropping has the potential to increase the long-term sustainability of food production under low inputs systems. The inclusion of short-duration intercrops like rajmash, lentil and maize for green cobs in autumn-planted sugarcane help is generating additional mid season income and thus alleviating the socio-economic status of small and marginal cane growers. Besides providing higher system profitability, intercropping of legumes also improves soil health and makes the plant– ratoon system sustainable. Even after knowing the numerous advantages of intercropping practices as an efficient way of utilizing natural resources like sun and soil along with its preferred technology implementation, it is still lacking in its implementation on a large scale by sugarcane growers in India. Now days, it is the time for developmental personnel to transfer fruits of innovation to the farmers with whole package of practices. Several practices such as arrangement of credit facilities to the farmers, supplying seeds of suitable crop sand varieties along with involvement of sugar factory personnel will improve the economic condition of the farmers of our country. Special emphasis must be given to manage sugarcane after the harvest of the intercrop.

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