Indian Farming 75 (12): 61-64; December 2025

Sugarcane + maize intercropping:

A next-generation approach to achieve food-energy-water security and biofuel self-reliance in India

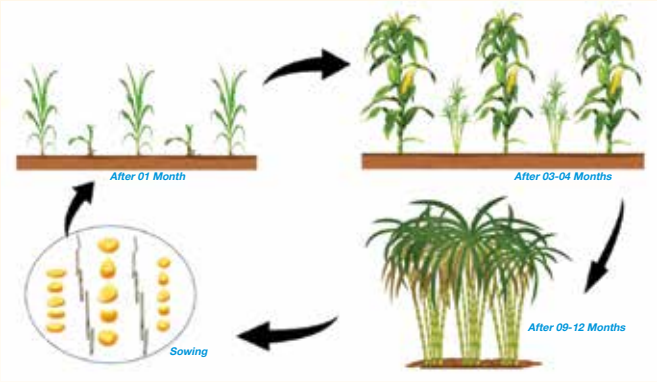
S. L. Jat[1], Manish Kakraliya[1], Pashupat Vasmatkar[2], D. M. Mahala[2], Ph. Romen Sharma[2], Abhijit Mandal[3] and H. S. Jat[2]*

[1]*ICAR-Indian Institute of Maize Research, Delhi Unit, Pusa Campus, New Delhi 110 012*
[2]*ICAR-Indian Institute of Maize Research, Ludhiana, Punjab 141 008*
[3]*ICAR-Indian Agricultural Research Institute, New Delhi 110 012*

Monoculture of sugarcane in India is causing inefficient resource utilization and delayed economic returns. To overcome these limitations, sugarcane+maize (SM) intercropping system has emerged as a sustainable and profitable alternative. The system strategically integrates maize during sugarcane's initial slow growth phase, thereby improving land and water use efficiency while ensuring an additional income to farmers. Maize, with its short growth cycle, complements sugarcane by utilizing otherwise underutilized resources and diversifying farm output. Beyond food and feed, maize grain also serves as a potential feedstock for dual-feed distilleries, thereby supporting India's bioethanol production targets. Recent on-farm field demonstrations have showed that SM intercropping increases sugarcane equivalent yield (SEY) by approximately 28% over sole sugarcane (150 t/ha) and translating into significantly higher net profits (₹ 1,25,000/ha). The maize yield of 4–8 t/ha was achieved in various agroecologies in SM system. The SM system has the potential to expand on to 15 lakh hectares which can produce more than 60 lakh tonnes of maize. SM intercropping also helps in strengthening biofuel security in India.

Keywords: Bioethanol production, Profitability, Resource use efficiency, Sugarcane-maize intercropping

SUGARCANE (*Saccharum officinarum* L.) is one of India's most important commercial crops. However, growing it as a sole crop poses several challenges including inefficient resource utilization during its slow initial growth, high water demand, and delayed economic returns due to its long cropping duration. Moreover, the sugarcane crop gives income to the farmers after almost 10–15 months which may pose a hardship to the farmers in managing their daily expenses. Mono-cropping of sugarcane increases vulnerability to pests and diseases, further impacting productivity, profitability, resource use efficiency, and overall sustainability. Additionally, the water-intensive nature of sugarcane cultivation exacerbates pressure on already limited water resources in many regions of India. The crop ecosystem further suffers due to the non-functioning of its industries around the year. Recently, the Government of India's initiative and support for clean fuel led to the intalllation of dual feed-based ethanol producing plants in sugarcane areas. In these dual-feed distillaries, apart from sugarcane and it's byproduct (molasses) grains primarily maize is being utilized to produce bioethanol which is being used in the belended petrol programme of the Government. Therefore, these distilleries are becoming increasingly important for the overall sustainability of sugarcane



Crop cycle of sugarcane and maize crops in sugarcane+maize intercropping system


Sugarcane and maize crops at tasselling and cob formation stages in sugarcane + maize intercropping system in Solapur, Maharashtra

ecosytems in the country. However, the non-availability of the maize grain for feedstock is a serious challenge as there is not enough area for growing the crop nearby sugar industries.

To overcome these limitations, intercropping sugarcane with short-duration crops like maize (*Zea mays* L.) could be a promising strategy to enhance resource (land and water) use efficiency, improve soil health, and provide supplementary income to farmers. The maize can mature in 90–120 days and can efficiently utilize the initial slow growth period resources used in sugarcane cultivation. Hence, the intial period of slow growth in sugarcane can be effectively used for cultivation of maize as an intercrop. Research at ICAR-IISR indicated the green cob harvesting potetail for sugarcne + maize intercropping system. As this is going to be a new system for grain prodcution, broad guidelines on its cultivation are provided in this article based on the available lietarure and on-farm studies in vaious agro-ecologies in India.

Management practices for sugarcane+maize intercropping

Climatic requirements: Sugarcane is best suited to tropical climates, but can also be successfully grown in sub-tropical areas. Maize, on the other hand, thrives in temperatures ranging from 9–46°C with the optimum temperature around 34°C. However, exposure to temperatures exceeding 32°C, as well as frost, can diminish yield during the reproductive period. The ideal soil temperature for germination and seedling growth is 26–30°C. The sugarcane is planted in southern India in July/August or the rainy season while the spring season planting of sugarcane in northern India can be successfully intercropped with maize.

Soil type: Sugarcane and maize crops exhibit adaptability to a wide range of soil types, from sandy loam to clay loam, making them versatile for cultivation under diverse agro-climatic conditions. However, maize is highly sensitive to waterlogging and water scarcity, necessitating precise water management for optimal growth and productivity. On the other hand, soils with high organic matter content, high water-holding capacity, and a neutral pH (6.5-7.5) are ideal for more productive growth of both crops.

Cultural practices

Sowing time: In northern India, mid-February to mid-March is the optimum time for planting sugarcane which aligns well with the ideal sowing time for spring maize across different agroecological regions of India. In southern India, anytime sowed sugarcane can have maize as intercrop. However, in the ratoon sugarcane crop, maize can be plated just after harvesting the planted sugarcane crop throughout India.

Method of sowing and spacing: Sugarcane should be planted in rows 75–100 cm apart and 20–25 cm deep trenches. After placing the setts in trenches, cover them with 5 cm of soil. Maize should be sown simultaneously on the ridges of sugarcane with 25–30 cm plant spacing. Apply irrigation immediately after planting, if planting is not done under sufficient moisture (Vattar) conditions. The paired row planting of sugarcane (75:150 cm) interval facilitates better intercropping opportunities. In this, two rows of maize can be placed in 150 cm space available.

Seed rate: Use 50,000 three-budded setts or 37,500 four-budded sets or 30,000 five-budded setts per hectare of sugarcane. For manual sowing of maize by hand, the seed rate varied between 12–15 kg/ha. However, the seed rates of maize of 12 kg/ha when using a hand-push plant seeder is sufficient.

Seed treatment: To promote sugarcane germination, it is recommended to soak the setts in an Ethrel 39 SL solution, using 25 ml of the product dissolved in 100 L of water for 24 h before planting. For maize, the seeds should ideally be pre-treated but if required, then applied Imidacloprid @4 g/kg of maize seed or a combination of Cyantraniliprole 19.8% + Thiamethoxam 19.8% FS @6 g/kg of seed to protect against fall armyworm infestations. However, maize hybrid seed bought in market mostly treated, if produced by own, the seed treatment is required.

Detopping and *in situ* drying of cob for quality production in sugarcane + maize intercropping system

Nutrient management

At the time of planting, apply a full dose of phosphorus (P_2O_5) and potassium recommended for sugarcane. The recommended nitrogen in sugarcane be applied as one-third at planting, and the remaining two-thirds in equal splits during the tillering and grand growth stages. In addition to this, for maize, N should be applied at 100 kg/ha, which is divided into two equal splits at knee-high and tasselling stages near the root zone of maize plants. For this, apply 1 bag (45 kg) of urea/acre each at knee-high and tasselling stages.

Water management

Applying irrigation for sugarcane and maize in the ridge and furrow system would be ideal where water is applied in furrows up to a third of the height of ridges or beds. Most of the time, the irrigation schedule of the sugarcane be followed for sugarcane + maize intercropping system. The moisture-sensitive stages of maize i.e. seedling, knee high, silking, and grain filling should be assured moisture if it is not twinning with the sugarcane schedule. The use of drip irrigation system can improve performance and yield of SM system further.

Weed management

- ***Manual weeding:*** Perform two to three hoeing operations using a hand-operated rotary weeder to manage weeds in the intercropping system.
- ***Chemical control:*** Effective weed control involves timely herbicide application during various crop growth stages. The percentage of yield losses in maize ranges from 25–80%, and is greatly influenced by the type of weeds present, duration of the crop-weed competition, and the density of weeds.

Table 1. Recommended herbicides for sugarcane+maize intercropping system

Herbicide Name	Type	Dose (a.i. g/ kg per ha)	Formulation (g/ml/kg/L per ha)	Dilution in Water (L)
Atrazine 50% WP	Pre-emergence	500–1000	1000–2000	500–700
Topramezone 10 g/L + Atrazine 300 g/L SC	Post-emergence	766	2500	500
Halosulfuron Methyl 75% WG	Post-emergence	67	90	375
Mesotrione 2.27% w/w + Atrazine 22.7% w/w SC	Post-emergence	865	3460	500

Pest and disease management

Effective pest management is equally crucial for maintaining the overall health of the crops and ensuring optimal yields. Apply Azoxystrobin 18.2% + Difenoconazole 11.4% w/w SC at a concentration of 0.03% (0.3 g/L) or with a formulation of 0.1% (1 ml/L water) to control blight and downy mildew in maize, as well as red rot, smut, and rust in sugarcane.

Table 2. Recommended insecticides for sugarcane+maize intercropping system till harvest of maize

Insecticide Name	Dose (a.i. g/ha)	Formulation (g or ml/ha)	Dilution in Water (L)	Insect-pest
Chlorantraniliprole 18.50 % SC	37	2000	500	Fall armyworm and borers
Flubendiamide 2 20 % WG	50	250	500	

Handling and processing of maize

- ***Harvesting:*** In intercropping systems, maize is typically harvested first to avoid interference with the growth and development of sugarcane. The maize cobs should be harvested when the grains reach physiological maturity, which is usually marked by the formation of a black layer at the base of the kernel. Cut the remaining green maize stalks at ground level and use them as animal fodder.
- ***Threshing:*** After harvesting, the next step is to separate the kernels from the cobs using mechanical maize shellers or threshers for efficiency. Once the kernels are removed, it is crucial to ensure proper drying of the grains to reduce their moisture content to 12–14%. This moisture range is ideal for safe storage and prevents issues like mild growth, insect infestations, or spoilage during storage.

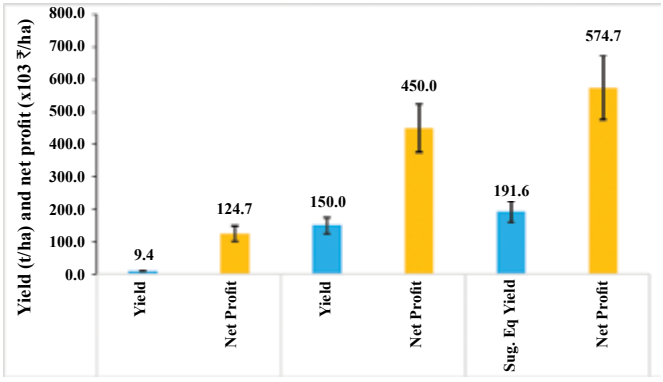
Crop yield and profitability

The on-farm demonstrations were done at the farmers' fields in Solapur Maharashtra in *khairf* and *rabi* season. Sugarcane+maize (SM) intercropping recorded the highest net profit of ₹575 x 10^3 ₹/ha, which is 125 x 10^3 ₹/ha higher than sugarcane sole, and saved ₹ 1,01,000–₹1,48,000/ha. In terms of yield, SM intercropping (~192 t/ha) achieved ~28% more sugarcane equivalent yield (SEY) than sugarcane sole (150 t/ha). Therefore, a significant economic advantage of SM Intercropping over sugarcane monocropping system, making it a more productive and profitable option for farmers. The farmer harvested 4–7 t/ha.

Sugarcane+maize intercropping system was demonstrated in 50 acres by Indian Institute of Maize Research (IIMR). This system is being expanded from Maharashtra to Haryana, and Eastern and Western Uttar Pradesh during the spring 2025. Farmers harvested 4–7 t/ha of maize in *kharif/rabi* season in Solapur. The maize income covered the entire cost of sugarcane cultivation comfortably. In spring planted sugarcane, farmers harvested impressive maize yield of 5–7 t/ha.

Key Interventions of SM intercropping system

- ***Deploy simplified crop management:*** Common weed and pest management and synchronized reduced labour, input cost, and improved system efficiency.



Crop yield and net profit of sole maize and sugarcane, and their intercropping

Sugarcane + maize intercropping system Bulanshahr, Uttar Pradesh

- ***Short to medium duration hybrid:*** High-yielding, short/medium-duration maize hybrids ensured compatibility with sugarcane and stable yields across ecology to be taken. The maize crop to be detopped or harvested before active tillering stage. Green cob purpose maize to be taken, its duration is longer to avoid adverse effect on sugarcane.
- ***Resource-efficient intercropping:*** Maize cultivated during the first 3 months of sugarcane with 50–75% plant stand (20–25 thousand/acre), synchronized water management, and additional 2 urea bags/acre as top dressing maximized the efficiency.
- ***Detopping and green fodder use of maize:*** The detopping of maize done at 70–90 days (at brown husk) and green fodder can be fed to animal; it will have better insolation for sugarcane. The cob will be dried *in situ* for better grain quality.
- ***Sustainability and profitability:*** Reduced inputs, higher resilience, and dual-feed ethanol support improved farmer income and timely payments.
- ***Scalability:*** The SM model has potential to expand on to 15 lakh hectares of yearly planted sugarcane (1/3rd acreage) and can produce >60 lakh tonnes of maize especially for dual feed ethanol industries. It will increase farmer profitability and resource use efficiency for sustainable sugarcane production.

SUMMARY

Sugarcane+maize intercropping system optimizes land and water use, boosts farmer income, and supports bioethanol production. By efficiently utilizing sugarcane's slow initial growth phase, maize enhances soil health and reduces weed pressure. This system increases farm profitability, promotes sustainability, and strengthens India's clean fuel initiative, making it a viable solution for future agriculture.

*Corresponding author email: hsjat_agron@yahoo.com