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GOOD AGRONOMIC PRACTICES IN CORN CROP FOR ETHANOL PRODUCTION

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Total global ethanol production is 110 billion litres, in which the USA and Brazil account for 84% of global ethanol production (92 billion litres), followed by the European Union, China, India, Canada, and Thailand (2019-20) (UN Department of Energy, 2021)

- India has got all the potential to produce ethanol, as raw materials required for ethanol production is available abundantly in the country.
- Ethanol burns more completely than petrol, hence avoids carbon monoxide emission.
- National Policy on Biofuels (2018) – The Government has set the target to achieve 10% ethanol blending in petrol by the end of 2022 and increase it to 20% by 2030. And the policy further amended in June 2022. Considering the achievements in this field in the recent past, Government has decided to advance the target of 20% ethanol blending in petrol by 5 years from 2030 to 2025 (Ministry of Petroleum and Natural Gas, 2023)
- India's current production capacity of ethanol is 426 crore litres from molasses-based distilleries and 258 crore litres from grain-based distilleries. This is expected to increase to 760 crore litres and 740 crore litres, respectively and this would suffice to produce 1016 crore litres ethanol required for the ethanol blending programme and 334 crore litres for other uses. In 2025, this will require 6 million tonnes of sugar and 16.5 million tonnes of grains per year
- In 2020-21, India's net import of petroleum was 185 million tonnes worth $55 billion. Successful 20% ethanol blending in petroleum products could save the country $4 billion/annum(NITI Aayog and Ministry of Petroleum and Natural Gas, 2021).

Field maize is highly suitable for ethanol production as it is rich in starch content because ethanol is made from starch. Select those varieties which are engineered strictly to produce ethanol, which have enzymes within the kernel needed to refine biofuel. The enzymes break down starch for fermentation. Ethanol plants using such corn varieties no longer need to purchase the enzyme (Alpha amylase) for the fermentation process. Example: A biotech corn named 'Enogen' from Syngenta - the first corn genetically enhanced for ethanol production

Agronomic Practices to Be Followed To Get Good Quality Corn Crop for Ethanol Production

- **Climatic and Soil Conditions:** Maize cultivation requires warm weather, deep, fertile, and well-drained loam and medium to heavy soil. Soils with good organic matter, high water holding capacity, and neutral pH (6.5-7.5) are considered ideal for higher productivity.Saline and alkaline soils are not suitable for maize cultivation. The ideal temperature for maize germination is 21°C and for growth is 32°C. It tends to thrive well where the night temperature does not go beyond 15.6°C.Maize is grown in areas receiving rainfall between 500 mm to 1000 mm. The crop is highly susceptible to frost, water-logged and moisture stress conditions, particularly during the early stages of growth.

- **Growing Season**

Season	Sowing	Harvest	States
Kharif	Last week of June to first fortnight of July	Mid-September-February	Karnataka, Andhra Pradesh, Maharashtra, Madhya Pradesh, Uttar Pradesh
Rabi	Last week of October as intercrop to first fortnight of November as sole crop	Late March-July	Bihar, Punjab, Uttar Pradesh, Coastal regions of Andhra Pradesh, Karnataka

- **Intercropping system**
  - Maize + Pulses (Pigeon pea/Cowpea, Maize/Blackgram/Greengram/Soybean)
  - Maize + High value vegetables
  - Maize + Flowers

- **Land Preparation for Sowing**

One deep ploughing immediately after rabi crop harvesting (2-3 deep ploughings in case of heavy soils) - One light ploughing - Planking

- **Sowing Method**
  - **Raised bed (Ridge) planting:** The best planting method during monsoon and winter season. For optimal germination, it is recommended to sow or plant on the southern side of the east-west ridges. This method saves around 20-30% of irrigation water with higher productivity and also the furrows act as drainage channels.
  - **Other methods of planting/sowing:** Zero-till planting, Conventional till flat planting, and Transplanting
- **Seed Treatment:** Treatment of seeds with fungicides and insecticides to protect the crop from seed and soil borne diseases and insect-pests

Disease/Insect-pest	Fungicide/Pesticide	Rate of application (g/kg of seed)
Turcicum leaf blight, Banded leaf blight and Sheath blight, Maydis leaf blight	Bavistin + Captan (1:1)	2
Brown stripe downy mildew	Apran 35 SD	4
Pythium stalk rot	Captan	2.5
Termite and Shoot fly	Imidachloprid	4

- **Seed rating:** Field corn type- 17-20 kg/ha
- **Spacing and plant population:**
  - 60 cm × 20 cm - 83,333 plants/ha
  - 75 cm × 20 cm - 66,666 plants/ha
- **Planting depth** - 5 cm to10 cm, depending on the soil type and planting date (Planting should be shallower in heavier soils thanin sandy soils)
- **Nutrient management:** Apply 10 tonnes of FYM per hectare 10-15 days prior to sowing and 158-180 kg N, 70-80 kg P_2O_5, 70-80 kg K_2O and 25 kg $ZnSO_4$ per hectare. Full P, K, and Zn should be applied at the time of sowing.N should be applied in 5 split doses as given below for higher productivity and nutrient use efficiency.

Sl. No.	Crop stage	Nitrogen (%)
1	Basal (At sowing)	20
2	V_4 (Four leaf stage)	25
3	V_8(Eight leaf stage)	30
4	V_T(Tasseling stage)	20

Sl. No.	Crop stage	Nitrogen (%)
5	GF (Grain filling)	5

(or)

Fertilizer apply period	Kharif (per ha.)	Rabi (per ha.)
1st(before sowing *Land preparation)	DAP: 50 kg/ MOP: 50 kg / Zinc Sulphate: 10 kg	DAP: 60 kg/ MOP: 60 kg / Zinc Sulphate: 10 kg
2nd (25-30 days *After germination)	Urea: 50 kg/ DAP: 25 kg/ MOP: 10 kg	Urea: 60 kg/ DAP: 35 kg/ MOP: 15 kg
3rd (45-50 days *Before flowering)	Urea: 50 kg	Urea: 60 kg

- **Water management:**
  - ✓ The irrigation should be provided in furrows up to two-third height of the ridges
  - ✓ Most critical stages of irrigation - Young seedling stage, Knee height stage (V_8), Flowering stage (V_T), and Grain filling stage (GF)
  - ✓ In raised bed planting system and limited water availability conditions - Irrigate alternate furrows to save more water
  - ✓ In rainfed areas - Tied-ridges are proves beneficial in conserving rainwater for an extended duration at the root zone
  - ✓ For winter maize - Keep soil moist (frequent and mild irrigation) between15th December to 15th February to protect the crop from potential frost damage

- **Weed management:** Weed control during first 6-8 weeks after planting is very crucial in maize. The major weeds are:Bermoda grass, Nut grass, Small burnyard grass, Crowfoot Grass, Green Foxtail (Narrow leaf weeds), Carrot Grass, Jangliimli, Common spurge, white cock's comb, Purslane, Green amaranthus, Asian yellow spider flower, Giant pig weed, White goosefoot(Broad leaf weeds)

Methods of weed control are as follows:

- ✓ **Physical methods -** Removal of weeds either mechanically or manually
- ✓ **Cultural practices -** Winter ploughing, crop rotation, planting of crop in wide rows for mechanical control
- ✓ **Chemical methods -**The herbicides listed in below are broad spectrum in nature hence effective against both narrow and broad leaf weeds in maize crop.

Herbicide	Formulations	Dose (gmai/acre)	Time of application (DAS)
Atrazine	50 % WP	300	0-2
Topramezone	33.6 % SC	12	20-30
Tembotrione	34.4% SC	50	20-30

Pest management: The major pest in maize are Maize stem borer, Pink stem borer, Shoot fly, White grub, Cut worm, Hairy caterpillar, Thrips, Aphid, Army worm, and Temites.

Integrated Pest Management

- ✓ **Cultural practices:** Deep summer ploughing, use of well decomposed farm yard manure, intercropping with legumes, proper planting spacing (75cm×18cm in Kharif and 60cm×18cm in Rabi), balanced use of fertilizers (NPK 120:60:40 kg/ha) and supplement of micronutrient, proper water manangement.
- ✓ **Genetic management:** Use of resistant varieties like HQPM 1, DHM 117, HM4, HM5, Vivek Hybrid 5, Pisa Composite 3, Amar.
- ✓ **Mechanical practices:** Removal of dead hearts, use of bird scarer, manual collection and destruction of white grub and chaffer beetle.
- ✓ **Biopesticides:** Soil application of neem cake for control of nematode and chaffer beetle.
- ✓ **Biological control:** Conservation of naturally occurring biocontrol agents such as *Trichogramma chilonis Ishii*., Carabids, Coccinellids, spiders and wasps, etc. and by reducing chemical pesticides, release of *Trichogramm achilonis* @ 1,60,000 /ha on 7 and 15 days old crop and subsequently if required.
- ✓ **Chemical control:** To control stem borer, shoot fly and thrips, apply Carbofuran 3% CG @33.3kg/ha directly into the whorls of infested plants. Spray Carbaryl 85% WP @ 1764 g/l to control borer at 15-18 days after germination. For managing shoot flies, spray Monocrotophos 36% SL @ 625 ml/ha or Dimethoate 30% EC @ 1155 ml/ha or Oxydemeton - methyl 25% EC @ 1000 ml/ha or Phorate 10% CG @ 30 kg/ha.

Disease management: The major diseases in maize are Turcicum leaf blight, Maydis leaf blight, Fusarium stalk rot, Chalk rot, Banded leaf and sheath blight, Common rust, and Brown stripe downy mildew.

Integrated Disease Management

- ✓ **Cultural practices:** Select field with good drainage, sanitation and removal of plant debris, 2-3 times deep ploughing, proper seed bed preparation, use of balanced fertilizer, avoidance of moisture stress at critical stages of plant growth.
- ✓ **Genetic management:** Use of disease resistant varieties like PEMH-5, Vivek 21, PrathapKanchan 2, PAU 352, DMH 1, NAC 6002.
- ✓ **Mechanical practices:** Stripping two lower leaves along with the leaf sheath, roguingand destroying infected plants and alternate hosts, and utilizing bird scarer to prevent seed damage.
- ✓ **Biological control:** Utilizing *Trichoderma harzianum* formulation 2.0% WP @ 10 g/kg in furrows at the time of sowing prior to mixing with FYM and incubated for 10 days in moist condition for Charcoal rot. Seed treatment with *Trichoderma harzianum* 2.0% WP @ 20 g/kg of seeds for control of banded leaf and sheath blight, combined application of mustard and tobacco dust @ 2.5q/ha (ETL-2 cyst/g of soil) for cyst nematode, on weekly interval application of *Trichogramma chilonis* @ 1,60,000/ha on 7 and 15 days old crop for various pathogens.
- ✓ **Chemical control:** Seed treatment with Thiram 75% WS @ 25 to 30 g/kg seed and Metalaxyl-M 31.8% ES @ 2.4 ml/kg of seed(Downy mildew). Foliar Spray of Mancozeb 75% WP @ 1.5 to 2 kg/l of water at first appearance of leaf blight followed by 2 to 4 applications at 10 days interval if needed.Spray Zineb 75% WP @ 1.5-2 kg/ha at firstappearance of Common rust and three sprays of fungicide at 15 days interval, if needed.

- **Harvesting:** Harvest the maize cobs mechanically when kernels are matured with 25-30% moisture

Maturity period for harvesting of maize

Varieties	Days after planting	Suitable areas
Long duration	100-120	Areas, where irrigation for early sowing is available or rainy season, starts early
Medium duration	85-95	Where late sowing is done and irrigation is available
Short duration	80-85	Where sufficient rainfall is available or grown as intercrop
Very short duration	75-80	Riverside areas where sudden floods are caused

- **Post-harvesting care:**
  - Harvested cobs should be dried before threshing and dry kernels sufficiently before storage
  - Use proper machines to avoid losses in threshing and winnowing
  - Proper follow up of sanitary measures during drying, packing, and handling
  - Adopt grading practices for proper evaluation
  - Use proper packaging material (Jute bags are ideal) for transportation and storage
  - Follow proper scientific storage techniques and maintain optimum moisture content
  - Use pest control measures like fumigation before storage
  - Provide aeration to stored grain and stir grain bulk occasionally

Feedstock Requirement for Ethanol Production: (All units in %dry basis)

Typical analysis of Maize	Moisture	Starch	Protein	Fibre	Fat	Ash	Other soluble	Total
	14.00	70.00	9.50	11.50	3.90	1.60	3.50	100.00

High starch content in maize is desirable because higher the starch content, higher the ethanol production from unit quantity of maize

- 1 MT of maize at 60% starch produces 360 litres of ethanol
- 1 MT of maize at 70% starch produces 420 litres of ethanol

Hence, 1 tonne of starch will produce around 620 litres of ethanol

Conclusion

As per the report by the Institute for Energy Economics and Financial Analysis (Worringham, 2022), India needs to allocate an additional 30,000 sq. km of land for maize cultivation in order to achieve its target of 20% ethanol blending in petrol by 2025. In India, sugarcane is the cheapest source for ethanol production. 1 ton of sugarcane yields 100 kg of sugar and 70 litres of ethanol. However, the production of sugar from sugarcane requires a significant amount of water, with 1 kg of sugar necessitating 1600-2000 litres of water, while 1 litre of ethanol from sugarcane requires approximately 2860 litres of water. Therefore, ethanol production from sugarcane places higher demands on water resources, and expanding sugarcane cultivation could potentially jeopardize the country's food security. As an alternative feedstock for ethanol production, cereals, particularly maize, offer promising prospects. The fibrous by-product after the extraction of ethanol from maize grain acts as an

excellent animal feedstock called distillers grains and can be further processed for the production of corn syrup, corn flour, corn chips, and corn flakes, which can maximize profitability for producers.

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