4. Clustering Maize Plants – Science & Technology

A recent study published in Science by researchers from Zhejiang University (China), in collaboration with the Netherlands and Switzerland, found that clustering maize plants enhances insect resistance through plant–soil signalling.

Plant Communication Mechanism in Maize

Overview - Plants, though immobile, possess sophisticated mechanisms to perceive, signal, and respond to environmental threats. In maize (Zea mays), one remarkable mechanism involves chemical communication between neighboring plants to enhance defense against pests and pathogens.

Mechanism of Communication

Volatile Organic Compounds (VOCs) - When maize plants are attacked by herbivorous insects, they emit linalool, a volatile organic compound with a floral scent.
Neighbouring Plant Alert - Linalool acts as a signal to nearby plants, activating defense responses preemptively even before they are attacked.
Experimental Observation - Plants situated in the middle of dense plots showed significantly less insect damage than edge plants, indicating that plant density amplifies chemical signalling, providing stronger protection in crowded clusters.
Trade-Off Between Growth and Defense - While linalool-mediated defense protects plants against pests, it comes at a cost - slower growth and reduced biomass production. This illustrates the growth-defense trade-off, where plants allocate resources either to growth (yield) or defense (resistance to biotic stress).

Key Compounds Involved in Defense

1. **Linalool -** Acts as a volatile signaling molecule. Industrial relevance in perfumes, soaps, and flavoring agents. Triggers defense pathways in neighboring plants.
2. **Jasmonates -** Plant hormones that mediate stress and defense responses. Activated in roots upon exposure to linalool, inducing downstream protective mechanisms.
3. **HDMBOA-Glc -** A defensive metabolite released into the soil. Enhances populations of beneficial bacteria, which in turn stimulate salicylic acid signaling in neighboring plants. Provides broad-spectrum defense against pests, nematodes, fungi, and viruses.

Broad-Spectrum Protection Provided

Insect Pests - Reduced damage from fall armyworm (Spodoptera frugiperda).
Nematodes - Decreased gall formation by root-knot nematodes (Meloidogyne incognita).
Fungal Pathogens - Increased resistance to Exserohilum turcicum (Northern corn leaf blight).
Viral Diseases - Reduced spread of rice black-streaked dwarf virus (RBSDV).

Broader Implications of Plant Communication

1. **Growth-Defense Trade-Off -**
   Plants must balance energy allocation between growth and defense.
   Dense planting enhances defense but may reduce productivity.
2. **Farmer Intervention -**
   Knowledge of linalool signalling could enable farmers to manipulate defense responses externally, reducing unnecessary pesticide usage.
3. **Plant Engineering -** Maize varieties could be genetically modified to either -
   1. Ignore linalool signals in low-pest environments for higher yield.
   2. Respond strongly in high-pest settings for lower crop losses.
4. **Sustainable Agriculture -** Leveraging natural plant signaling mechanisms reduces reliance on chemical pesticides, supports high-density cultivation, and promotes resilient farming systems.

About Maize (Zea mays)

Origin - Domesticated from teosinte in Mesoamerica ~9,000 years ago.

Global Importance - Known as the "Queen of Cereals" for its high yield potential.
Uses - Animal feed, human consumption (corn flour, starch, sweeteners), biofuel, and industrial raw materials (plastics, alcohol).

Maize in India

Introduction - Brought by Portuguese traders in the 17th century.
Production - Ranked 5th globally; 14th largest exporter. 2023–24 (3rd Advance Estimates) - 35.67 million tonnes, area 9.96 million hectares, average productivity ~3.1 t/ha (global avg. 5.7 t/ha).
Major States - Karnataka, Madhya Pradesh, Bihar, Tamil Nadu, Telangana, Maharashtra, Andhra Pradesh.
Seasons - Grown in Kharif and Rabi.
Agro-Climatic Requirements - Warm and moist climate; optimal temperature 21 –27°C. Rainfall requirement - 50–90 cm, well-distributed. Soil preference - Fertile, well-drained alluvial and loamy soils.

Challenges in Maize Cultivation

1. **Pest Vulnerability -** Monocultures attract insects and pathogens.
2. **Climate Change Risks -** Global maize productivity could fall by up to 24% by late 21st century.
3. **Low Productivity in India -** Yield (~3.1 t/ha) lags behind global average due to pest stress, nutrient management issues, and limited irrigation.
4. **Resource Constraints -** Soil degradation, water stress, and fragmented landholdings reduce efficiency.

Integration of Plant Communication in Sustainable Farming

High-Density Planting - Enhances natural defense but requires careful management to prevent yield loss.
Bio-Priming and Soil Microbes - Using HDMBOA-Glc signaling to enrich beneficial soil microbiomes improves overall crop health.
Genetic Approaches - Breeding maize that optimally balances growth-defense trade-offs for specific agro-climatic conditions.
Reduced Chemical Use - Exploiting plant signaling reduces dependency on pesticides, promoting environmental sustainability and farmer income stability.
Source - https - //www.thehindu.com/sci-tech/science/clustering-maize-plants-together-can-improve-their-insect-resistance/article70104803.ece