Drought Tolerant Crop

Why in News?

Recently, a study has noted that a common weed named **“Portulaca oleracea”**, commonly known as **purslane**, offers important clues about creating **drought-tolerant crops** in a world beset by **climate change.**

- Yale University scientists integrated **two metabolic pathways** to produce a novel type of **photosynthesis** that enables the weed to **withstand drought while remaining highly ‘productive’.**

What do we know about Purslane?

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- **About:**
  - **Purslane** possesses evolutionary adaptations that allow it to be **both highly productive and drought tolerant.**
- **Description:**
  - It is mostly **an annual, but it may be perennial in the tropics.**
  - **Stems** are glabrous, fleshy, purplish-red to green, arising from a taproot, often prostrate, forming mats.
- **Distribution:**
  - It is most common in the **temperate and subtropical regions**, although it extends into the **tropics and higher latitudes.**
- **Habitat:**

    - **It is common in** fields, gardens, vineyards, lawns, driveways, dunes, beaches, salt marshes, waste areas, eroded slopes, bluffs and riverbanks.
- **Species Affected:**
    - It competes for resources with many field crops, particularly **herbaceous species** that are **germinating or growing in competition.**
    - **Affected crops include:** asparagus, red beets, celery, crucifers, cotton, maize, onions, potatoes, rice, soyabeans, sugarcane, tomatoes and wheat.
- **Ecology:**
    - **It has a wide tolerance of** photoperiod, light intensity, temperature, moisture and soil type.
    - Seeds germinate under conditions that **enhance the survival of seedlings**.
        - The species is **self-compatible.**

What are the Key Highlights of the Study?

- Plants have **independently evolved various mechanisms to improve photosynthesis,** the process by which green plants use sunlight to synthesise nutrients from carbon dioxide and water.
    - **Corn and sugarcane** evolved C4 photosynthesis, which allows the plant to **remain productive under high temperatures.**
- Succulents such as **cacti and agaves possess another type called CAM photosynthesis,** which helps them **survive in deserts and other areas with little water.**
- Both C4 and CAM serve different functions but **recruit the same biochemical pathway to act as 'add-ons' to regular photosynthesis.**
- The study conducted a spatial analysis of gene expression **within the leaves of purslane and found that C4 and CAM activity is totally integrated.**
    - They **operate in the same cells, with products of CAM reactions being processed by the C4 pathway.**
        - This system provides unusual levels of protection for a C4 plant in times of drought.

What are C3, C4, and CAM plants?

- **C3 Cycle:**
    - It is also known as **Calvin Cycle.**
    - It is a cyclic reaction occurring in the **dark phase of photosynthesis.**
    - In this reaction, **CO_2 is converted into sugars** and hence it is a process of carbon fixation.
    - The Calvin cycle was first observed by **Melvin Calvin in chlorella**, unicellular green algae. Calvin was awarded Nobel Prize for this work in 1961.
    - Since the first stable compound in Calvin cycle is a **3 carbon compound** (3 phosphoglyceric acid), the cycle is also called as **C3 cycle.**
    - **C3 plant examples:** Wheat, Oats, Rice, Sunflower, Cotton etc.
- **C4 Plants:**
    - The C4 plants show a **different type of leaf anatomy.**
    - The chloroplasts are **dimorphic in nature.** In the leaves of these plants, the **vascular bundles are surrounded by bundle sheath of larger parenchymatous cells.**
        - These bundle sheath cells have chloroplasts.
        - These chloroplasts of bundle sheath are larger, lack grana and contain starch grains.
        - The chloroplasts in mesophyll cells are smaller and always contain grana. This peculiar anatomy of leaves of C4 plants is called Kranz anatomy.
    - Examples of C4 plants: **Maize, Sugarcane, Amaranthus.**
- **CAM Cycle:**
    - CAM is a cyclic reaction occurring in the dark phase of photosynthesis in the plants of Crassulaceae.
        - It is a CO_2 fixation process wherein the first product is malic acid.
        - It is the third alternate pathway of Calvin cycle, occurring in mesophyll cells.
    - CAM plants are usually **succulents** and they grow under extremely xeric conditions. In these plants, the leaves are succulent or fleshy.
        - In these plants, the stomata remain open during night and closed during day time.

        - The CAM plants are adapted to photosynthesis and survival under adverse xeric conditions.
    - **Examples:** Sedum, Kalanchoe, Pineapple, Opuntia, Snake plant.

Source: DTE