Agriculture, Vanilla too, is moving indoors

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http://www.ift.org/food-technology/past-issues/2019/march/features/indoor-growing.aspx

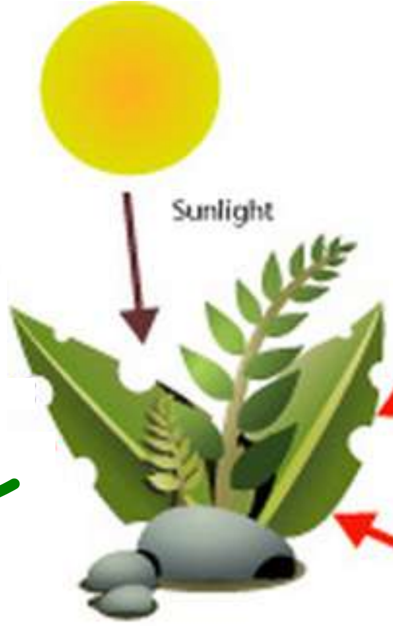
Agriculture is the science and art of cultivating plants for food, feed and fiber

Agriculture exploits the efficacy of plants to mine carbon dioxide from the atmosphere, and minerals and water from the soil for the propagation of living mass and for reproduction.

Fundamentals of Crop Production

Plants collect inorganic, non-living materials from the surrounding and convert them to organic, life-relate compounds.

The process depends on the utilization of sun energy (in photosynthesis)



Carbon dioxide from the atmosphere

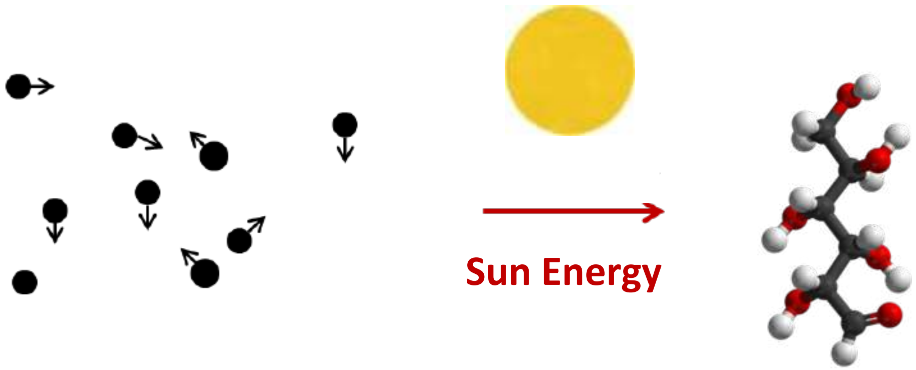
Organic

Inorganic

Sugars, proteins, DNA lipids and all other cellular components

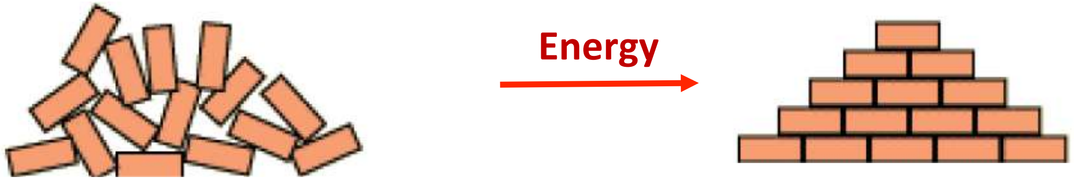
Nitrogen, minerals, water from the soil

Plants use the sun energy, captured by photosynthesis, for the conversion of atmospheric gaseous carbon dioxide (CO_2) to sugar.



A sugar structure showing organized carbon atoms obtained from CO_2

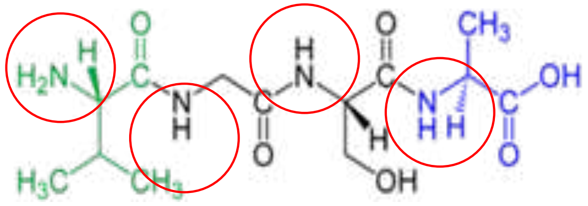
Carbon dioxide molecules dispersed in the atmosphere

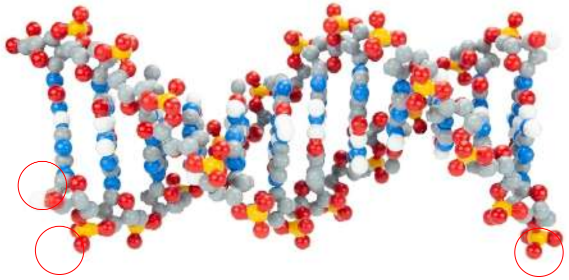


It takes energy (work) to create order from disorder

Another example of disorder to order:
Nitrogen dispersed in the soil is integrated into highly structured cellular constituents

Energy →





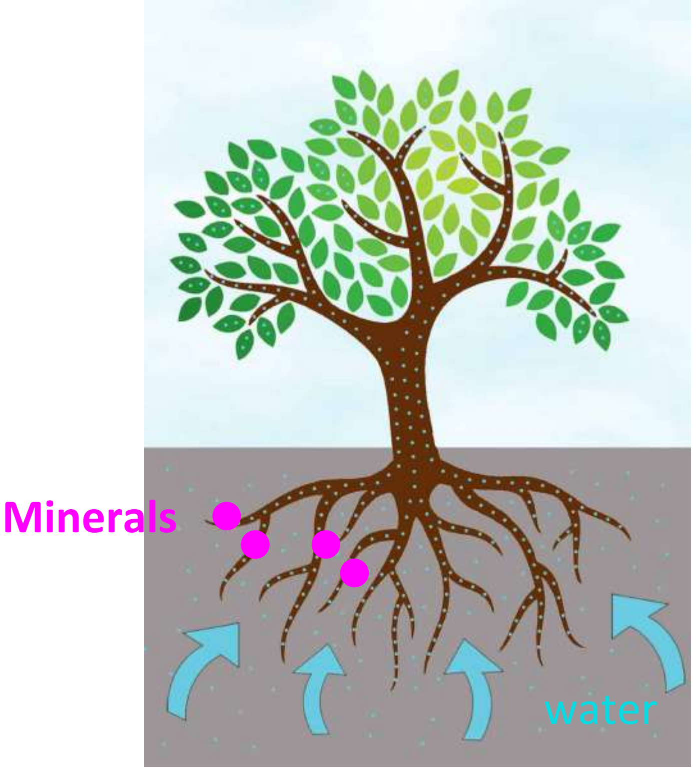
Nitrogen in the soil

Nitrogen ◯ in cellular protein

Nitrogen ◯ in DNA

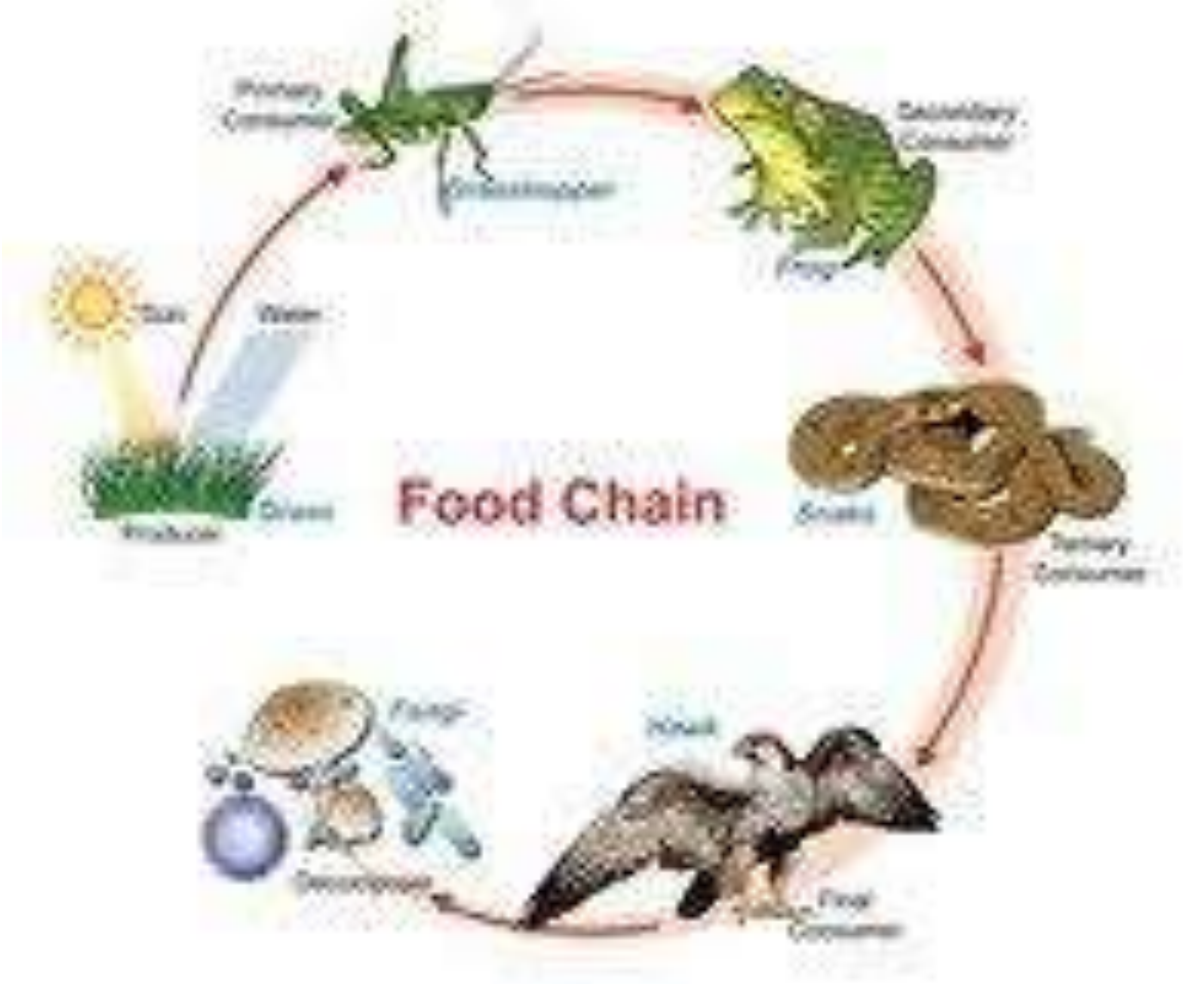
Plants collect nitrogen (nitrates or ammonia) from the soil and use metabolic energy to incorporate nitrogen into proteins, DNA and other cellular compounds.

Plants also mine from the soil water and minerals such as potassium, iron, copper or cobalt



Water comprises around 80% of plant mass and has many cellular and metabolic roles.

Minerals have many and important metabolic roles.



The ability of plants to use the sun energy to form life-related compound is the foundation of food chain in the biosphere.

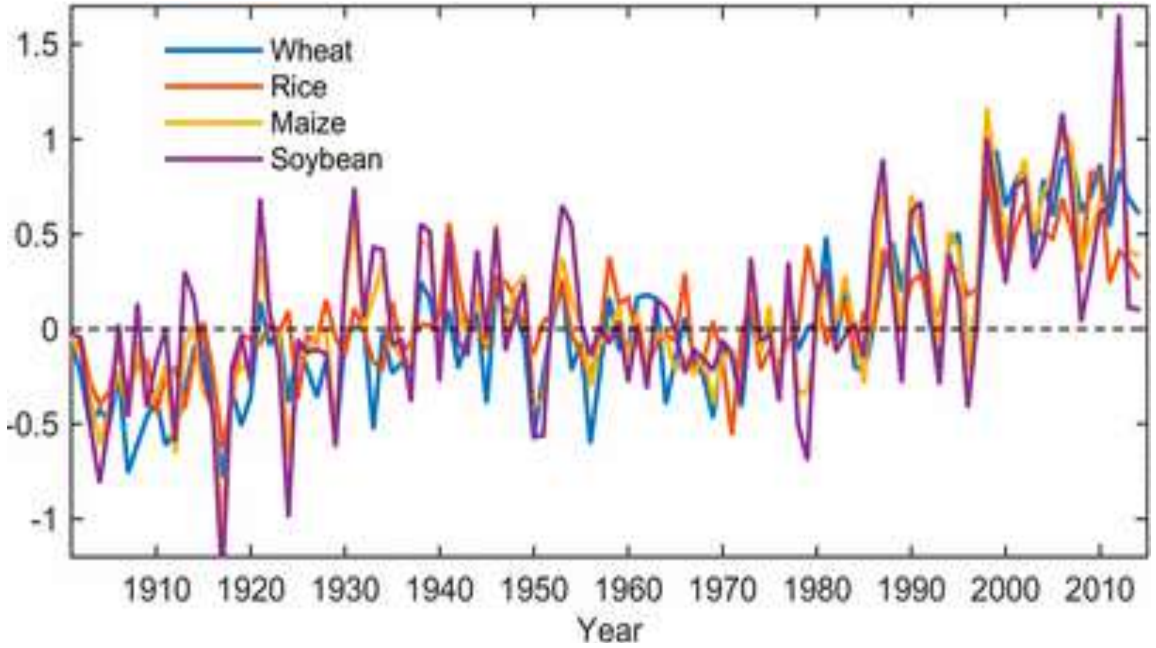
The ability of plants to use the sun energy to form life-related compound has been used traditionally by open-field agriculture for the production of food, feed and fiber

The process is also used for the production of the prized vanilla beans.

Open-field agriculture is unstable and insecure

Open-field agriculture is subject to unpredictable changes in the environment, resulting in instability and variability in crop yield and quality.

Yield



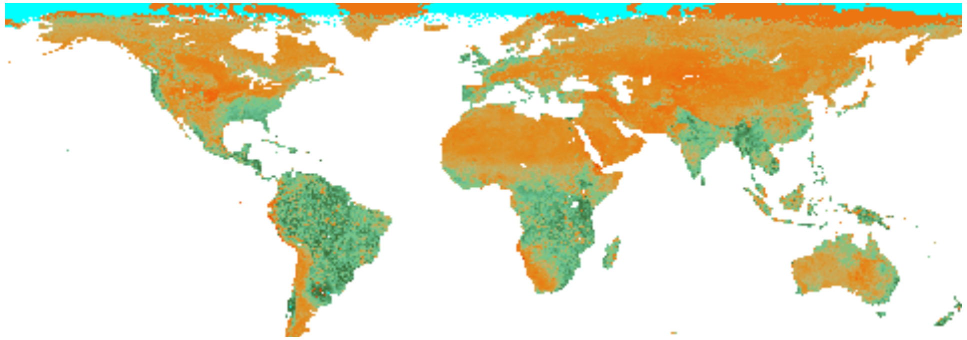
A graph showing yearly fluctuations in yield of wheat, rice, maize and soybean

Major reasons for variations in crop yield

- Drought
- Temperature extremes
- Wind
- Predation

Images showing global annual precipitation and global vegetation density

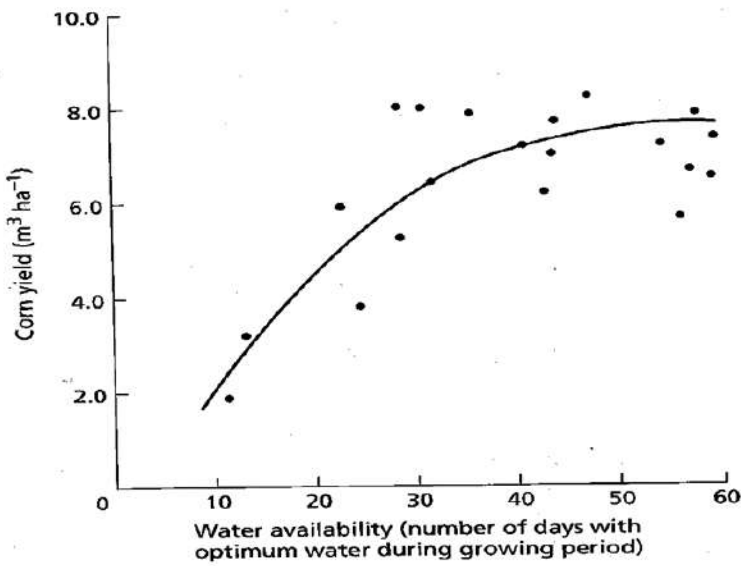
Global Annual Precipitation



Global Vegetation Density

Note a strong correlation between precipitation and vegetation density.

The previous graph showed that water is a decisive factor in plant productivity.
Water deficiency leads to significant reduction in plant yield.

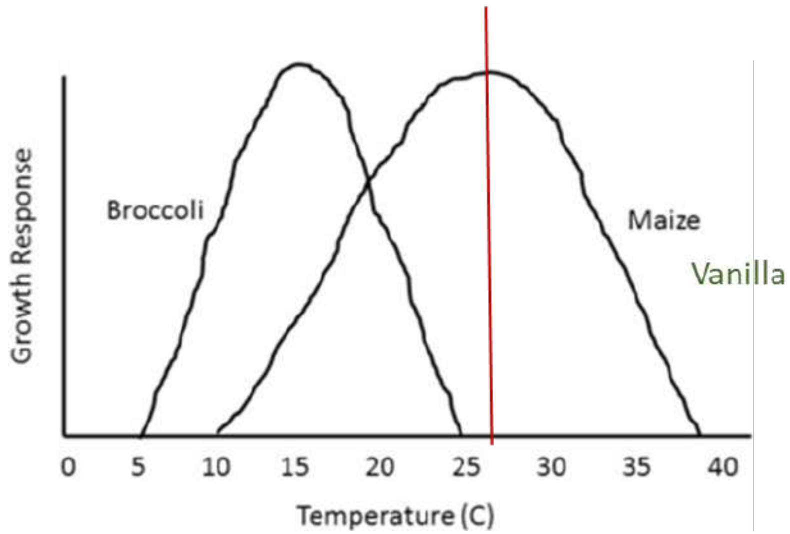


Corn yield on Iowa farm as function of water availability

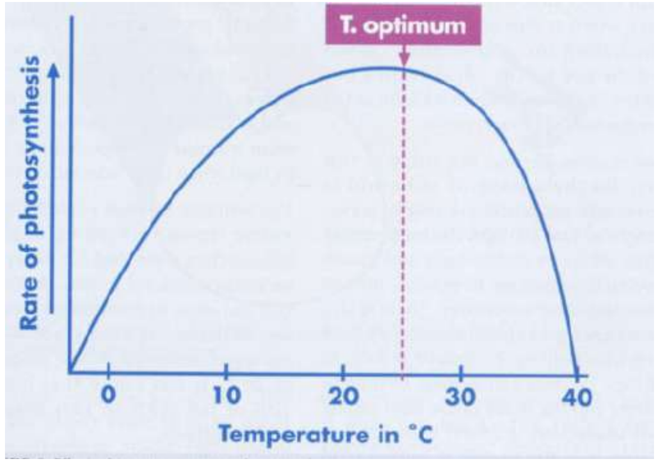
When water supply is restricted corn yield is low

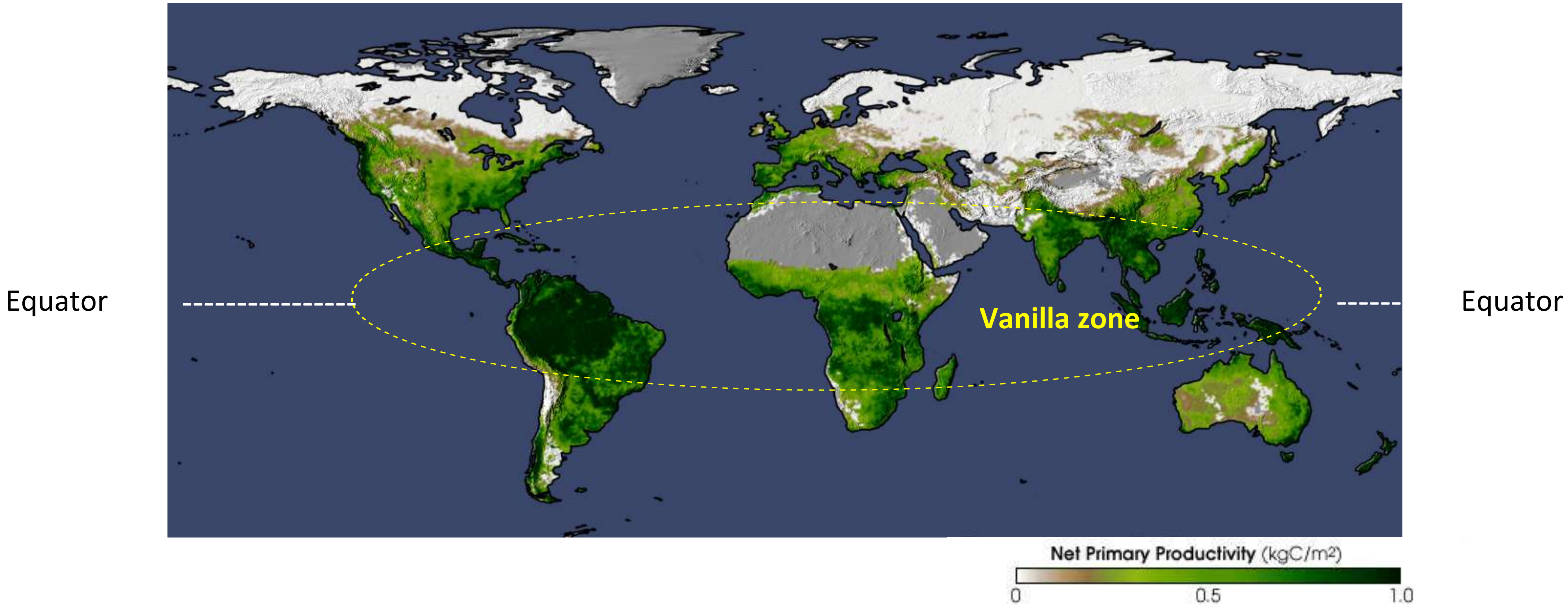
Temperature is also a critical factor in plant productivity

The optimal temperature for plant productivity is usually around 25 °C (77 °F), with some exceptions.



Photosynthesis, a basis for plant productivity, also manifest an optimum at 25 °C and profoundly influence the yield of plants.





An image showing Productivity of plants worldwide.

Plants are most productive around the equator, in part because of precipitation but also because the mean temperature in this zone, is around 25 °C.

Effect of temperature extremes on plant productivity

I-------------------------- Cold shock -------------------------I I-------------- Heat shock -------------------I

Chilling
(15 – 0 °C)

Freezing
(below 0 °C)

Heat
(30 °C and above)

Practically all tropical and sub-tropical plants are susceptible to chilling stress

Wind

In 2017 cyclon Enawo destroyed most of the vanilla crop in Antalaha, Madagascar(90-100%) and 80% of the crop in Sambava.

Predation

Predation, mostly by insects and disease, also decrease plant productivity.

Banana infected by Black sigatoka

Vanilla infected by fusarium

Controlled environment agriculture (CEA) seeks to overcome disruptions to plant productivity by the environment

Greenhouse production of lettuce and tomatoes

Greenhouse-grown vanilla

The appeal of Controlled environment agriculture (CEA):

1. Growing in an indoor environment offers control of:

- water supply
- air relative humidity
- temperature
- light intensity and quality
- gas composition
- protection against pests and disease

2. Control of soil temperature might also be important

Temperature fluctuates Temperature kept steady at 25 – 30 °C

An image showing cucumber plants grown on unheated and on heated soil

Water-filled pipes installed in the soil heat or cool the soil around crop roots.*

This method have achieved increased yield: 60% for lettuces, 20% for strawberries, 40% for cucumbers and 66% for basil.

* **The system, developed by Sustainable Agricultural Technologies, LTD, Israel**

3. Control of Flowering

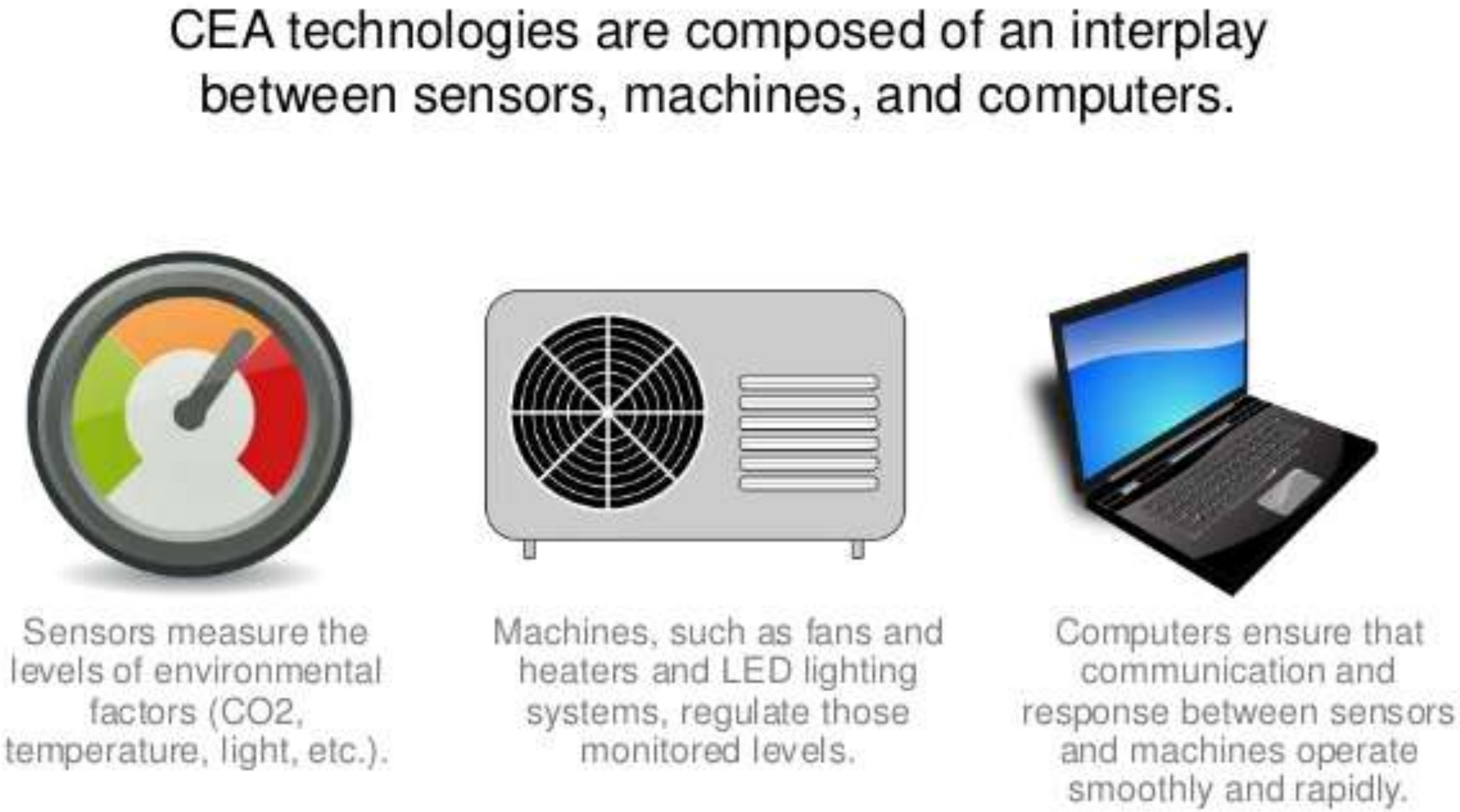
Production of green vanilla pods, the ultimate product of vanilla cultivation, is dependent of flowering.

Juan Hernandez (Mexico-INIFAP) observed that vanilla flowers the year-round at high elevations in Peru, perhaps because of high intensity of UV irradiation.

We will examine whether this light form can be expoited to stimulate flowering in greenhouse-grown vanilla.

In a greenhouse we can also create and control environmental conditions such drought, temperature extremes and nutritional stress known to accelerate flowering in vanilla.

Controlled environment agriculture (CEA) is precision agriculture guided by automation



4. Supply Chain Consistency- a primary asset of Controlled Environment Agriculture

Supply chain consistency is a fundamental requirement of any successful product or process.

Inability to establish consistency chokes and even brings down promising economic enterprises.

Manufacturing is based on ***steady*** supply of row materials with defined quality. Manufacturing cannot afford disruption in the supply of vanilla or in vanilla quality.

Vanilla production by Controlled Environment Agriculture (CEA) is sustainable. CEA and can supply vanilla beans with consistency and good quality.

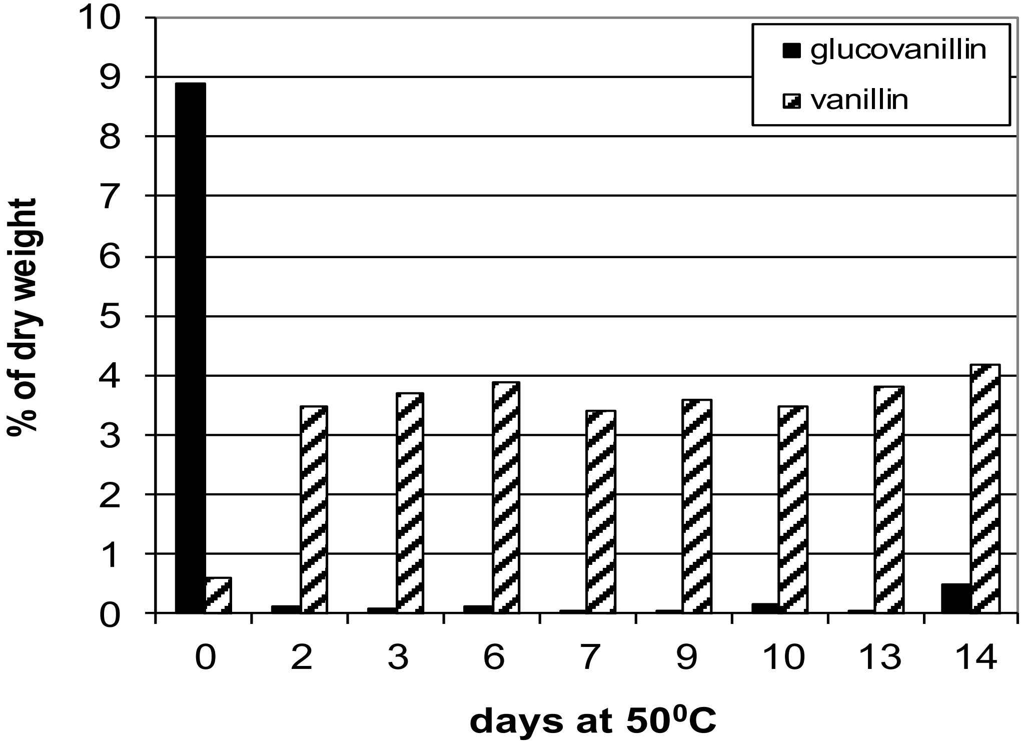
Supply consistency is a vital asset that is highly prized by the industry.

5. Locality

Production of plant crops in a controlled indoor environment is often local. It offers products with freshness.

Adoption of indoor agriculture has been driven by consumer demand for freshness and quality.

How ‘locality’ may play out in the vanilla business.



Daphna showed that curing of chopped beans leads to rapid release of vanillin from glucovanillin.

This curing method may be followed by on-site extraction of ‘Sweated’ chopped beans and save on time and cost of drying and conditioning of whole cured beans.

6. Authenticity

In commerce it is often difficult to verify the origin and authenticity of cured vanilla beans.

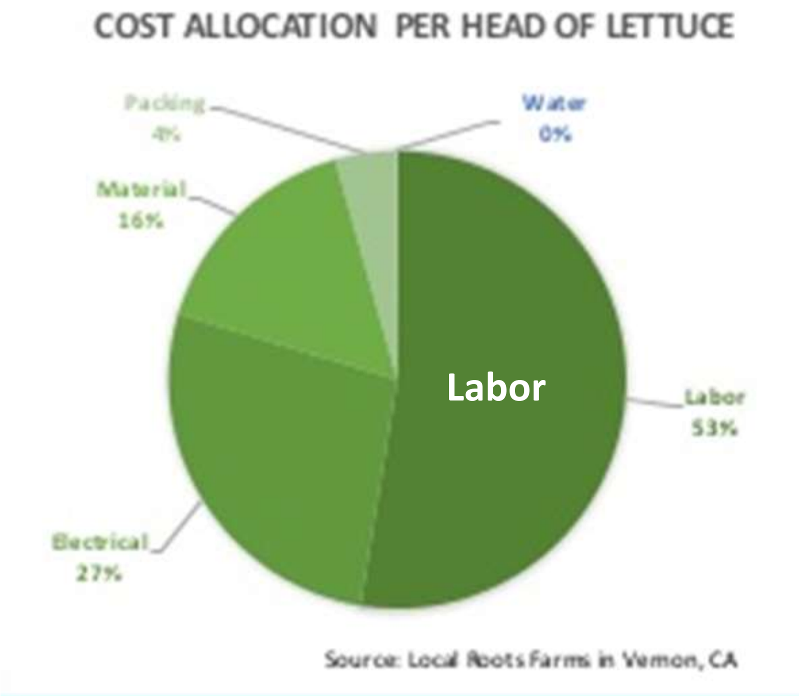
On-site cultivation, curing and extraction is validation of authenticity.

The CEA challenge: It’s expensive.

Starting an indoor growing operation is capital intensive.

Maintenance costs, mostly for lighting are high. (This problem may not apply to vanilla).

It is labor-intensive and, furthermore, labor-expensive, due to cost of skilled labor.



Summary

Controlled environment agriculture (CEA) offers sustainable crop production for yield and quality.
This asset is a highly prized by the vanilla industry.

On-site cultivation, curing and extraction is also a seal of authenticity.

High cost is a challenge to CEA-production of vanilla beans.

Thank you for your attention.

I welcome questions.

Wind and predation, mostly by insects and disease, also decrease plant productivity

Banana infected by Black sigatoka

Vanilla infected by fusarium

Perhaps savings on shipping cost when dry beans are used locally for vanilla extract.

An interesting possibility is extraction of wet ('sweated') beans at the production site, thus averting time and cost needed for drying and conditioning.

Mature-green beans

→

Killing

→

Sweating

→ Extraction