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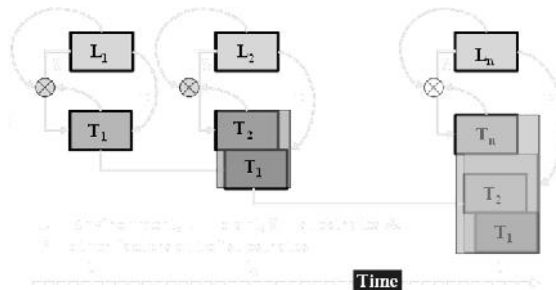
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LECTURE 02: PLANT AND ENVIRONMENT

Plant and Environment drive plant growth that causes *plant variation* as the core of plant growth analysis



The plant body at any moment is an epitome of the effects of past environments. Evans (1972)

LEARNING OUTCOMES

After the completion of this lecture and mastering the lecture materials, students should be able

1. to explain plant variability in relation to plant growth.
2. to explain the contribution of plants to plant variation.
3. to explain the role of genetic and other plant factors in the plant variation.
4. to explain the contribution of environment to plant variation.
5. to explain the importance of crop management to reduce unexpected plant variation in plant growth analysis.

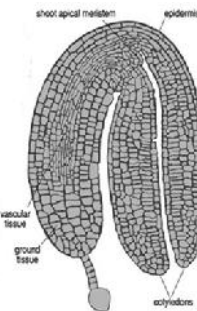
LECTURE OUTLINE

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|--|----------------------|
| 1. PLANT VARIABILITY | 3. Plant Response |
| 2. PLANT FACTOR | 4. Interaction |
| <ul style="list-style-type: none"> ● Genetics ● Embryogenesis ● Past effect ● Planting Materials | 4. CROP MANAGEMENT |
| 3. ENVIRONMENT | 1. Plant Arrangement |
| 1. Environmental Factors | 2. Crop Maintenance |
| 2. Species Richness | |

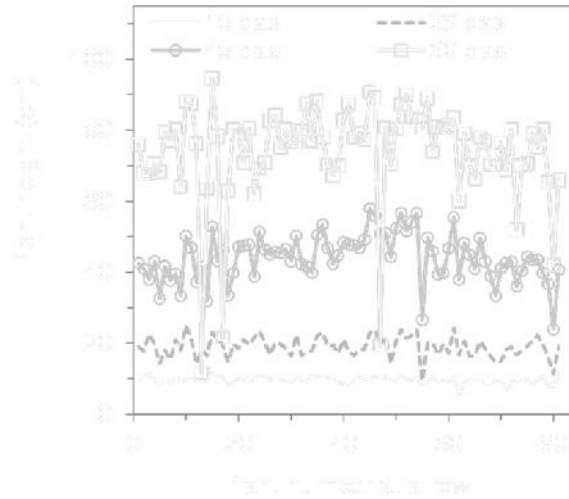
Chapter 2:
Sitompul, S.M. (2016).

1. INTRODUCTION

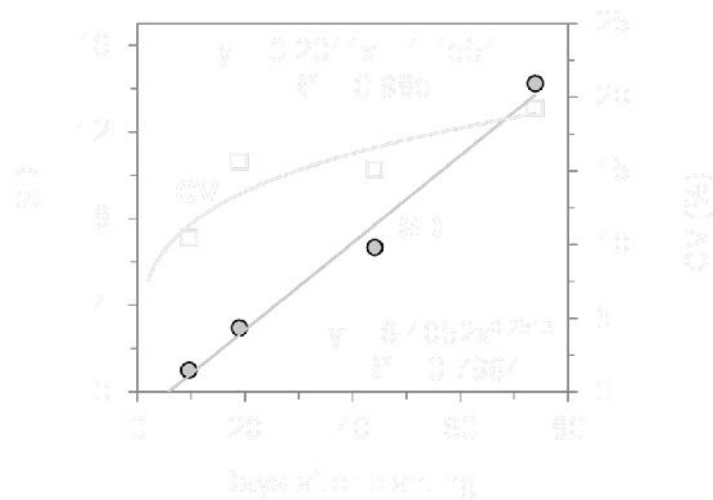
1. The core of plant growth analysis is plant variation with space and time that occurs since the initial stage (germination) up to the end of plant life cycle.
2. Plant variability is inevitable in the course of plant growth and development with time resulting from the changing expression of genetic program in space (plant parts) and time (the stage of plant life) in addition to the asymmetry configuration of plants including embryo.
3. As a consequence of many factors with their interactions that influence plant growth, the likelihood of very high growth variation between plants is plausible.



4. It is, therefore, not difficult to find growing plants on the same plots or rows to show variation such as the height variation of soybean plants.



5. The rate of variation increased with time resulting from the accumulation of variation and an increase in factors influencing the height of plants.



2. PLANT VARIABILITY

1. The plant growing in its natural environment is an object peculiarly inaccessible to scientific investigation.
2. Most of the experimental methods which have proved so successful in the laboratory would interfere destructively with the subject of the investigation, altering either the environment, or the plant, or both.
3. Great circumspection is therefore needed in the choice of methods.
4. It is necessary to consider carefully the nature of the biological and physico-chemical systems involved both when planning observations, and when considering the meaning of the results.

4. Plants during all phases of growth and development are affected by the environment ever-changing with time.
5. This fact brings about plant variability so it is difficult to get a plant grown under natural or semi-natural conditions into a particular state at a particular time.
6. Therefore, no experiment made under natural or semi-natural conditions can be repeated exactly, while often two successive sets of observations will show wide divergences.
7. The causes of these natural variations need to be examined to see how far it is possible to make allowances for them, or, indeed, to integrate them into the scheme which we are trying to construct of the life of the plant as a whole



8. Source of variation, not only factors under consideration but also those out of consideration, should be taken into account in the analysis of plant growth.
9. Variance (σ^2 , population & s^2 , sample) is a measurement of the spread between numbers in a data set, or is a measure of how far each number in the set is from the mean.
10. It is calculated as the average deviation of each number from the mean in the set of data as follows

$$\sigma^2 = \frac{\sum_{i=1}^n (x_i - \mu)^2}{n} \quad \text{or} \quad s^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}$$

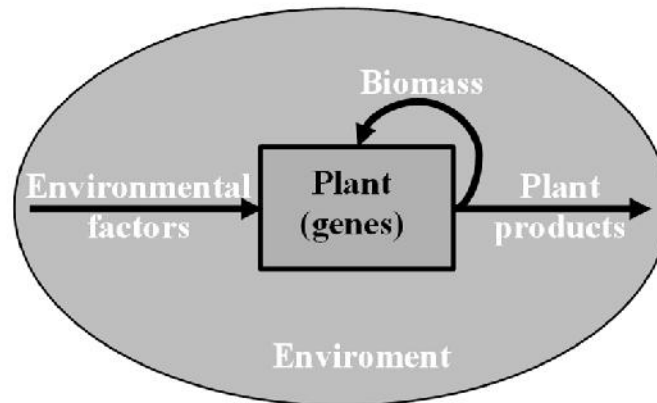
x_i is individual data point ($i = 1, 2, 3 \dots n$),

μ (\bar{x}) is mean of data points, and n = total number of data.

1. Plant Factor

- Plant factor as a source of variation is not confined to genetic factor, but also plant condition that may influence plant growth.
- It is necessary to underline that the role of plant condition in the growth of plants is huge due to the plant nature which is semiautonomous in the production of plant biomass.
- In other words, the plant itself produces its biomass using environmental factors as substrates under other environmental factors.
- Thus the plant body itself is the growth machinery (metabolism) that processes growth substrates to be plant biomass.

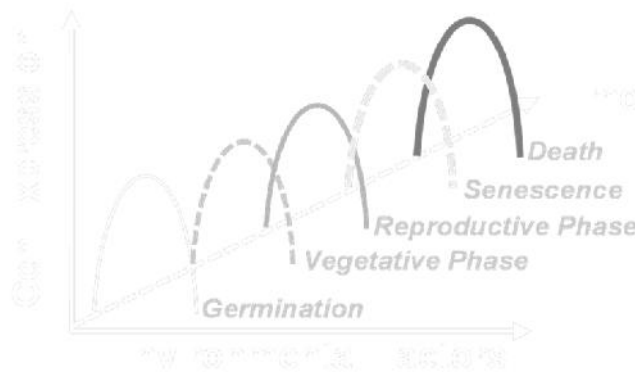
- The growth machinery is, of course, under the control of genetic program expressed through the synthesis of protein that is used as metabolic substrate or as enzymic component controlling metabolic reactions.



1.1 Genetic Factor

- A difference in plant growth associated with plant factor is often neglected such as planting materials (seeds or vegetative stakes) that come from the same variety and have been selected with certain criteria.
- Planting materials (seeds) of different genetic makeup are possible between seeds of the same variety resulting from cross-pollination.
- In maize, for instance, the probability of female flower to be pollinated by anthers from other plants is high.
- Different genetic program may be expressed at various plant characteristics including forms and functions of plants resulting in the variability of plant growth.

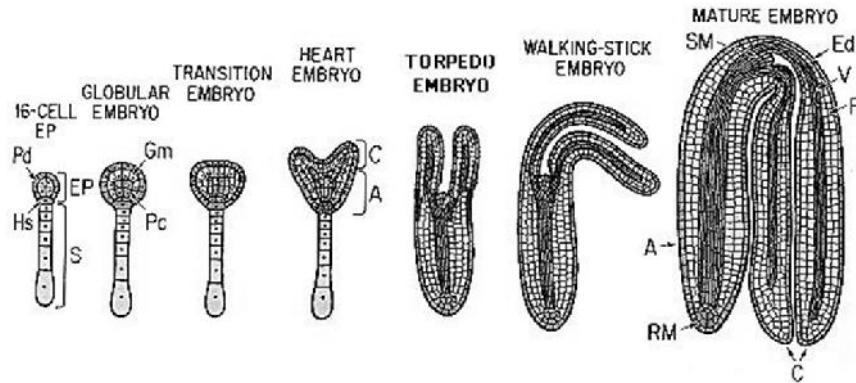
- The variability of plant growth attributed to genetic factor may increase with changing expression of genetic program with time corresponding with the progress of plant growth and environment.



1.2 Embryogenesis

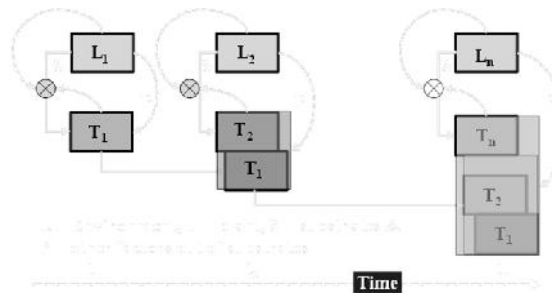
- The variability of plant growth could be started from embryogenesis attributed environmental factors or plant factor.
- Embryogenesis involves cell growth and division, cell differentiation and programmed cellular death.
- The zygotic embryo is formed following double fertilization of the ovule, giving rise to two distinct structures: the plant embryo and the endosperm which together go on to develop into a seed.
- Establishment of the major embryonic organs and shoot and root apical meristems occur through partitioning events along the apical–basal axis, and many of these events are guided by the hormone auxin.

- Formation of the three embryonic tissue systems occurs along a radial axis perpendicular to the apical-basal axis.



1.3 Influence of Past History

- The plant body grows gradually, tissues maturing progressively and being added to those matured earlier. As plants grow and mature, the tissues are affected by the current environment in various ways.
- The plant body at any moment is therefore an epitome of the effects of past environments.

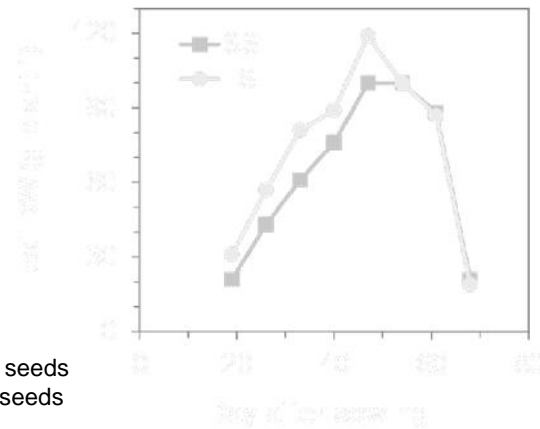


- It is this plant body which is reacting to the present environment, a fact to be remembered when studying plants which have grown in a natural, changing environment.
- Only rarely can experiments at different times be made on plants which embody the same structural history: and in consequence it is easy to carry out at different times two apparently identical experiments, whose results do not agree.
- To understand in detail the growth of a plant in a natural environment at any particular time, it would thus appear to be necessary to record in detail and to interpret the results of the past environments which have contributed to its make-up.

1.4 Planting Materials

- Planting materials such as seeds are the initial capitals of plant growth.
- Any difference in the quality of seeds (biophysical-chemical properties) may cause a difference in plant growth at initial stage and, hence, at later stages.
- Due to the fact that variability in biophysical-chemical properties of planting materials is very likely, planting materials would be one of potential sources of plant growth variation.
- It is, therefore, of great importance to use uniform planting materials from biophysical standpoint to enable adjacent plants to grow relatively similar in response to ever changing environment.

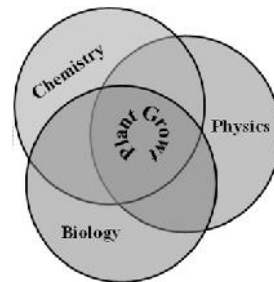
- In pea plants (*Phaseolus vulgaris* L.), a difference in plant growth was observed due to a difference in the size of seeds use as planting materials (Lima *et al.*, 2005).



3. ENVIRONMENTAL FACTORS

1. Variation of Environmental Factors

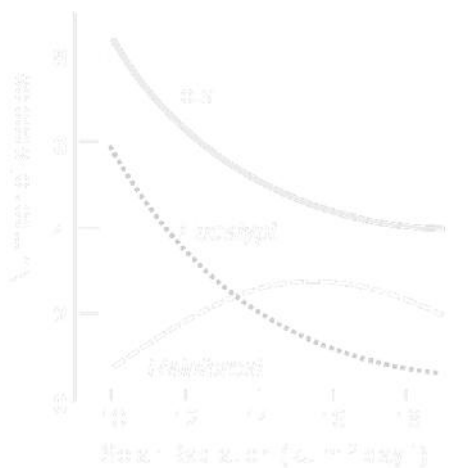
- Facts from the fields as to environmental factors important to bear in mind is that not all factors in the environment of plants support the growth and the life of plants. Some of the factors are even inhibitory for plant growth.
- When the environmental factors are divided into three groups (physical, chemical and biological factors), the existence of plants is found only in particular physical, chemical and biological milieu (habitats).



2. Plant Species Richness

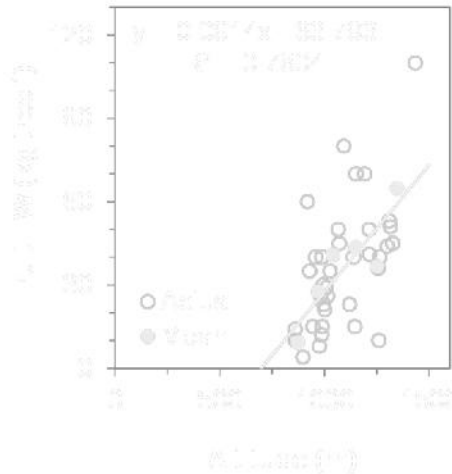
- Given the fact that plants are sessile, the relationship between plant and its environment tend to be specific in plant life. In other words, only certain plant species are able to grow and thrive well in particular environments that leads to species richness.
- Species richness is the number of different species represented in an ecological community, landscape or region. **Species richness** is simply a count of **species**, and it does not take into account the abundances of the **species** or their relative abundance distributions.
- An extreme case is mangrove that grow and thrive well on saline areas (coastal area) where most other plants species have no ability to survive.

- This asserts the interaction between genetic and environmental factors in the growth and development of plants.



Source: Austin *et al.* (1996)

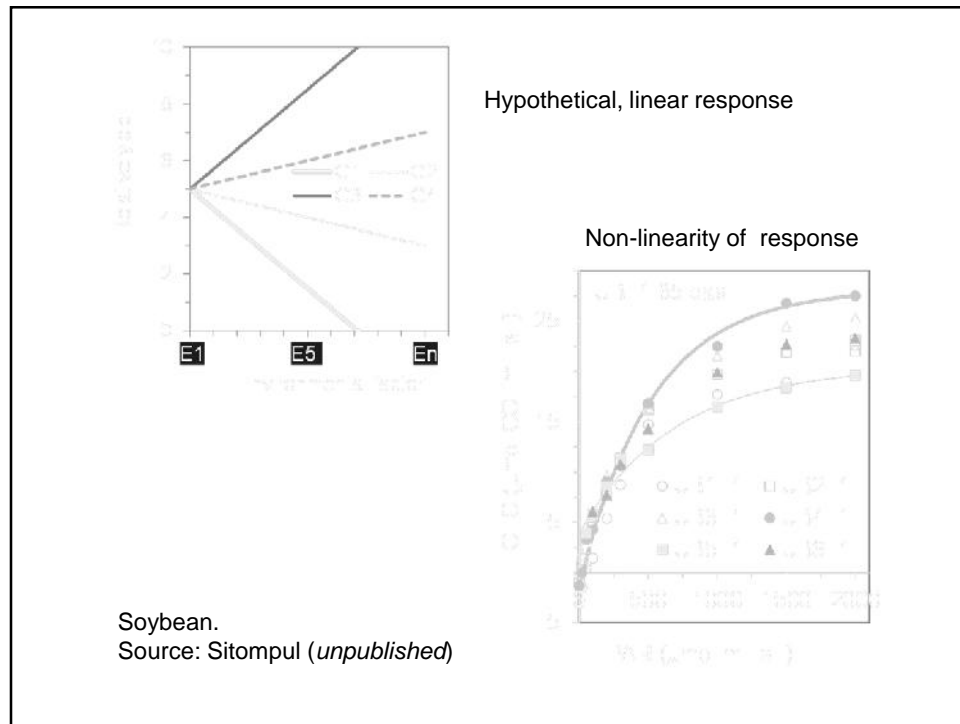
- The influence of environmental factors on plant growth controlled by genetic factor can be discerned in the productivity of apple trees that increased with altitude.



Source: Sitompul *et al.* (2012)

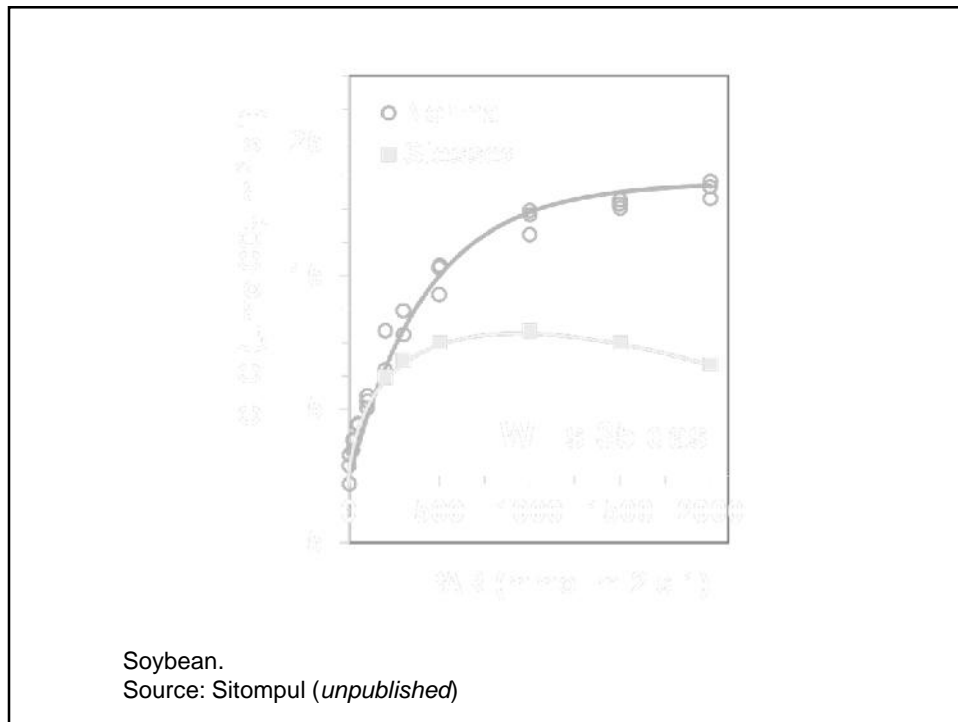
3. Plant Responses

- Other general aspects of the effects of environment on plant growth that must be considered at this stage are
 - the form of the response of the plant to changes in individual environmental factors, and
 - the nature of the interactions between the effects of one factor and those of another.
- The relationships between the different environmental factors and the reactions of the plant are rarely linear which is the most common model used to analyze the response of plants to environmental factors.
- Occasionally, one does find a very close approach to linearity over a specific range of factors under study.
- When a wide range of factors is applied, a more complex relationship would be found.



4. Interaction

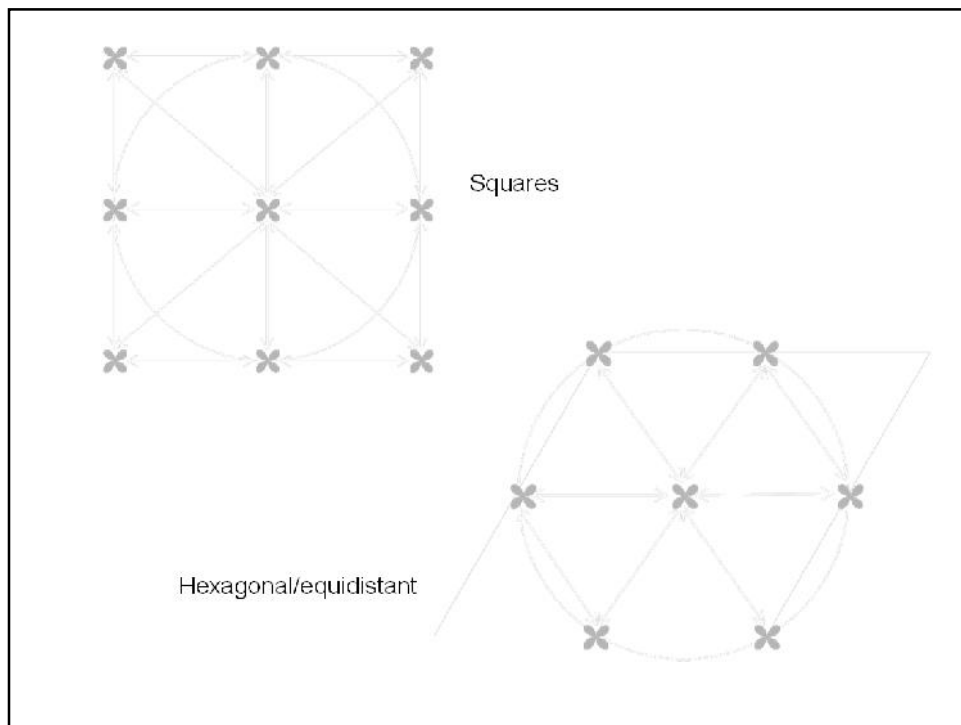
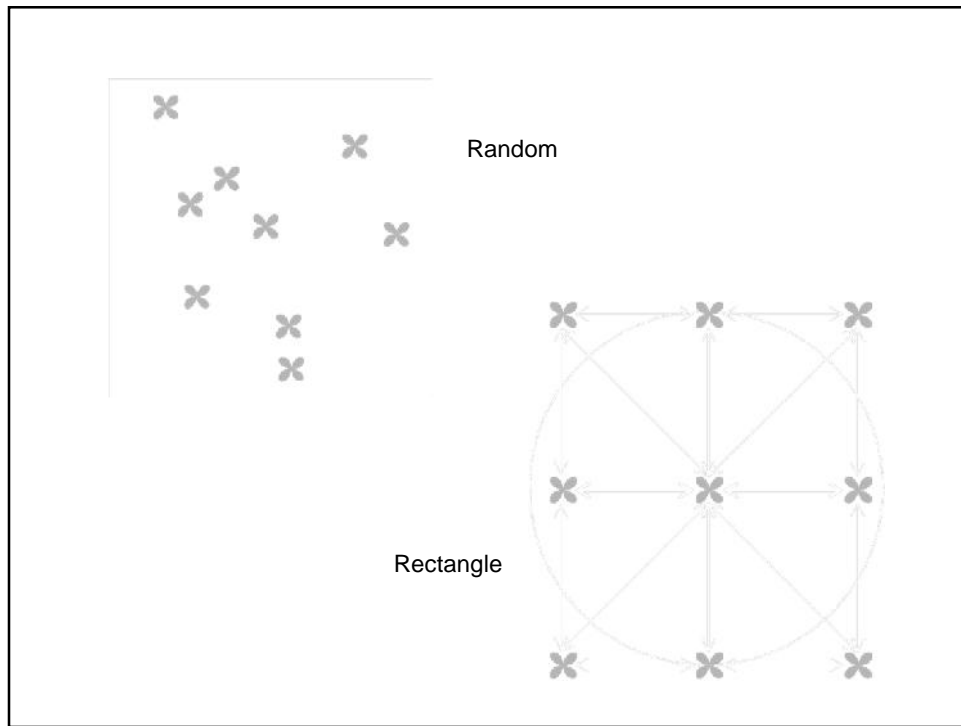
- Other aspects that should be also taken into account is the response of plants to two or more environmental factors.
- Plants growing in natural or semi-natural condition are always confronted with such circumstances as a change in one factor is often accompanied by a change in one or more factors.
- The complementary form of interaction, where two or more aspects of the environment all affect one particular aspect of growth, is very common.
- The complementary form of interaction can be illustrated with the response of normal plants and water-stressed plants to increasing light.



4. CROP MANAGEMENT

1. Plant Arrangement

- The manipulation of row spacing dimensions, plant populations, and the overall spacial arrangement of crop plants in a field has been the subject of considerable discussion among farmers and agronomists for many years.
- The crop canopy has often been manipulated by row spacing and population adjustments in an attempt to improve yields, production efficiencies, and profits.
- The basic principle that should be held in the case of plant arrangement is that all measures taken in the management of crops should be even for all individual plants.



2. Crop Maintenance

- The maintenance of crops or plants is necessary in plant growth analysis not only to obtain plants having good and normal growth, but also for other reasons associated with practices in the study of plant growth.
- The reasons, among others, are
 1. to obtain plants on the same plot which are relatively homogenous or not significantly different
 2. to elude factors other than treatments to influence experimental plants or to confound effect of treatments under study, and
 3. to elude factors outside the treatments to be limiting factors of plant growth.
- This maintenance may includes water supply, fertilizer application, and the control of weeds, pests and diseases.



WHAT HAVE YOU GOT?

1. What is the core of plant growth analysis?
2. What do factors cause plant variation with time and space?
3. Why are plants of the same variety growing side by side never be the same?
4. Does plant variation increase or decrease with time?
5. Why are plants growing in their habitat object peculiarly inaccessible to scientific investigation?
6. What is a simple meaning of variance?
7. What important is the role of plant condition in plant growth?
8. What does it mean by influence of past history in the context of plant growth?
9. How is the effect of increasing light quanta on the photosynthesis of stressed and unstressed leaves?
10. What are efforts that can be applied to reduce unexpected variability of plants?

