Crop geometry, plant population and yield relationship and plant density

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Crop Geometry

The arrangement of the plants in different rows and columns in an area to efficiently utilize the natural resources is called crop geometry. Shape of the space available for individual plants. Depends upon the,

Light interception,
Rooting pattern and
Moisture extraction pattern

Plant population , crop yield while on other side yield may also reduce due to lesser plant population below optimum due to inability to intercept maximum available light by poor plant stand (Mahajan, 2010).

Planting Pattern

Planting pattern influences crop yield through its influence on light interception, rooting pattern and moisture extraction pattern. Different planting patterns are followed to suit different weed control practices and cropping systems. Plant geometry refers to the shape of plant while crop geometry refers to the shape of space available for individual plants. Crop geometry is altered by changing inter and intra-row spacing.

Square planting

It is reasonable to expect that squares arrangement of plants will be more efficient in the utilization of light, water and nutrients available to the individual's than in a rectangular arrangement. In wheat, decreasing inter-row spacing below the standard 15-12 cm *i.e.*, reducing rectangularity, generally increases yield slightly. In crops like Tobacco, inter cultivation in both directions is possible in square planting and helps in effective control of weeds. However, square planting

is not advantageous in all crops. Groundnut sown with a spacing of 30x10cm (3.33 lakh/ha) gave higher pod yield than with same amount of population in square planting. Pod yield is reduced either by increasing rectangularity or approaching towards square planting.

Rectangular planting

Sowing the crop with seed drill is the standard practice. Wider inter-row spacing and closer intra-row spacing is very common for most of the crops, thus attaining rectangularity. This rectangular arrangement is adopted mainly to facilitate inter cultivation. Sometimes only inter-row spacing is maintained and intra-row spacing is not followed strictly and seeds are sown closely as solid rows.

Miscellaneous planting arrangements

Crops are sown with seed drills in two directions to accommodate more number of plants and mainly to reduce weed population. Crops like rice, finger millet are transplanted at the rate of 2-3 seedlings per hill. Transplanting is done either in rows or randomly. Skipping of every alternate row is skipped, and the population is adjusted by decreasing intra-row spacing, it is known as paired row planting. It is generally restored to introduce an intercrop.

Plant population and growth

A. High plant density brings out certain modifications in the growth of plants. Plant height increases with increase in plant population due to competition for light.
B. Sometimes it may happen that moderate increase in plant population may not increase but decrease plant height due to competition for water and nutrients but not for light.
C. Leaf orientation is also altered due to population pressure. The leaves are erect narrow and are arranged at longer vertical intervals under high plant densities. This is a desirable architecture.

Plant population and yield

Decrease in yield of individual plant at high plant density is due to the reduction in the no. or earls or panicles. Ex: - Redgram produces about 20 pods per plant at 3.33 lakh plants/ha (30x10cm) while it produces more than 100 pods per plant at 50,000 plants/ha (80x25cm).

Under very high population levels plant become barren, hence optimum plant population is necessary to obtain maximum yield.

Optimum plant population

Optimum plant population for any crop varies considerably due to environment under which it is grown. It is not possible to recommend a generalized plant population, since the crop is grown in different seasons with different management practices. E.g.:- Redgram plants sown as winter crop will have half the size of those grown in monsoon season. Optimum plant population is 55,000 plants/ha. For monsoon season crop of redgram and this is increased to 3.33 lakh plants/ha for winter crop; as low temperature retards the rate of growth, higher population is established for quicker ground cover.

In sorghum, when the climate is favorable during pre-anthesis period, the optimum population is two lakh plants/ha and when it is not convened for growth during pre-anthesis, it is four lakh plants/ha.

Solar radiation concept and harvest techniques

Solar radiation is the primary source of energy on earth, and life depends on it. Solar radiation is defined as “The flux of radiant energy from the sun”. All matter at a temperature above the absolute zero, imparts energy to the surrounding space. This energy is transformed by green plants in the process of photosynthesis into the potential energy of organic material. In inorganic bodies the rays absorbed are used in heating. The variations of the total radiation flux from one site to another on the surface of the earth are enormous and the distribution of plants and animals responds to this variation.

Solar radiation definition

Heat energy is transmitted by three processes.

1 Radiation

This is the process of transmission of energy from one body to another without the aid of a material medium (solid, liquid, or gas). **Example**: The energy transmission through space from the sun to the earth.

2 Conduction

This is the process of heat transfer through matter without the actual movement of molecules of the substances or matter. Heat flows from the warmer to cooler part of the body so that the temperature between them are equalized.

Example: The energy transmission through an iron rod which is made warmer at one end.

3 Convection

This is the process of transmission of heat through actual movement of molecules of the medium. This is the predominant form of transmission of energy on the earth as all the weather related processes involve this process. Example: Boiling of water in a beaker of the above three processes of transmission of energy convection is the predominant form of transmission of energy on the earth. All the weather related processes involve this process.

4. Solar Radiation: When the radiation is transmitted from the sun, it is known as solar radiation.

Solar spectrum

Radiant energy is transmitted in the form of electromagnetic waves by the sun. The energy from the sun is spread over a very broad band of wave lengths known as solar spectrum. It is also known as electromagnetic spectrum. The spectrum does not constitute only one band, but a combination of different waves which are characterized individually. **Example**: U.V. rays, light part, Near I.R., Far I.R. Radio weaves, micro waves, radar waves, *etc.*

Different bands of solar spectrum are:

A. The shorter wave lengths of the spectrum are known as U.V. rays. These are chemically very active. Unless these are filtered in the atmosphere, there is a danger for life on the earth. This band ranges between 0.005 to 0.4 microns.
B. The part of the spectrum which is visible known as `light'. It is the part of the spectrum which is essential for all the plant processes and ranges from 0.4 to 0.7 microns.

C. The third part of the solar spectrum (last band) is known infra red band. This is essential for thermal energy of the plant (the source of heat to the plant). This band is less than 0.7 microns.

Functions of light: The functions of light are:

1. All the plant parts are directly or indirectly influenced by light
2. Light of correct intensity, quality and duration is essential to normal plant development
3. Poor light availability causes abnormalities and disorders in plants
4. Light is indispensable to photosynthesis
5. Light governs the distribution of photosynthates among different organs of plants
6. Effects tiller production
7. Effects stability, strength and length of culms
8. Effects dry matter production
9. Effects the size of the leaves
10. Effects the root development
11. Effects the flowering and fruiting
12. Effects the dormancy of the seed

Solar constant:

It is the energy falling in one minute on a surface of 1 cm^2 at the outer boundary layer of the atmosphere, held normal to the sunlight at the mean distance of the earth from the sun. The units are $cal/cm^2/min$. "cal/cm^2 “is also known as "Langley". The estimated value of this constant is from 1.94 to 2.0 largely/min. The average value is 2 LY/mn.

It depends on:

1. Output of solar radiation.
2. Distance between the earth and the sun.
3. Transparency of the atmosphere.
4. Duration of the sunlight period
5. The angle at which the sun's rays strike the earth.

Net radiation

The difference between the incoming radiation from the sun and the outgoing radiation from the earth is known as net radiation. The net radiation values become –ve after late evening hours to early morning hours. It is a conservative term and plays an importance role in the energy processes of the crops.

Black body

It is an ideal hypothetical body which absorbs all the electromagnetic radiation falling on it. It neither reflects nor transmits any radiation striking it. However, when heated it emits all the possible wavelengths of solar radiation and Becomes a perfect radiator. So, an ideal black body is a perfect absorber and a perfect radiator.

Black body radiation

The radiation radiated by an ideal black body is known as black body radiation.

Emittance

It is the ratio of the emitted radiation of a given surface at a specified wavelength to the emittance of an ideal black body at the same wavelength and temperature. For other than a black body the value of emittance is always less than one and for black body the emittance value is one.

Absorptivity

For an object this is the ratio of the electromagnetic radiant power absorbed to the total amount incident upon the same object. Like emissivity the values are less than one for other than a black body and one for a black body.

Reflectivity

The ratio of the monochromatic beam of electromagnetic radiation reflected by a body to that incident upon it. The units of expression are by %.

Transmissivity

This is the ratio of transmitted to the incident radiation on a surface preferably a crop canopy.

Albedo

It is defined as the ratio between reflected radiation to the incident radiation on a crop field, snow, leaves etc. For white bodies the albedo values are high. For fresh snow cover the albedo values range between 75 and 95; for cropped fields, it is 12-13; dark cultivated soil 7-10; human skin 15-25, *etc*. Albedo determines how much of the heat that reaches the ground in the form of radiation will remain available for use.

Factors affecting the distribution of solar radiation within the plant canopy

Type of plants

The leaves cereal crops like paddy, wheat *etc*., have a transmissivity in the range of 5 to 10 per cent. The broad leaves of ever green plants have lower value of 2 to 8 per cent, whereas aquatic plants have the transmissibility of 4 to 8 per cent. Transmissivity changes with age of a leaf: the transmissivity of young leaves is more as compared to old leaves.

2. Chlorophyll content:

As the chlorophyll content increases the values of transmissibility decreases.

3. Arrangement of leaves

a) The relative light interception by horizontal and erect foliage is 1 : 0.44

b) When the leaf area index is one (i) the light transmissibility of more upright leaves is 74 as against 50 per cent for horizontal leaves

4. Angle of leaves

a) In full sunlight, the optimum inclination for efficient light use is 81°.

b) At full sunlight, a leaf placed at the optimum inclination is 4-5 times as efficient in using light as a horizontal leaf.

c) The ideal arrangement of leaves (shall be) is that the lowest 13 per cent of the leaves lay at angles between 0° and 30° to the horizontal, that the adjoining 37 per cent of the leaves lay at 30° to 60° and the upper 50 per cent of the leaves lay at 60° to 90°.

5. Plant density

In case of sparse crop stands not only the per cent of light transmissivity is more but it is also variable with the time of the day. It is minimum at noon and maximum during morning and evening hours. In dense crop canopies the light transmissivity is less.

6. Plant height

When the plant height increases the transmissivity of light by the canopy decreases.

7. Angle of the sun

a The highest radiation penetration occurs at noon

b. Relatively high radiation penetration also occurs both in the morning as well as before sunset due to high proportion of diffuse light.

The Dutch Committee on plant irradiation has divided the solar spectrum into the following eight bands. This was done on the basis of the physiological response of plants to the incident radiation.

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