# 19. GROWTH ANALYSIS

Growth analysis can be used to account for growth in terms that have functional or structural significance. The type of growth analysis requires measurement of plant biomass and assimilatory area (leaf area) and methods of computing certain parameters that describe growth. The growth parameters that are commonly used in agricultural research and the name of the scientists who proposed the parameters are given below.

| | | |
|---|---|---|
| LAI | - | Williams (1946) |
| LAR | - | Radford (1967) |
| LAD | - | Power *et al*. (1967) |
| SLA | - | Kvet *et al*. (1971) |
| SLW | - | Pearce *et al*. (1968) |
| NAR | - | Williams (1946) |
| CGR | - | Watson (1956) |
| RGR | - | Williams (1946) |
| HI | - | Nichiporovich (1951) |

**i. Leaf Area**

This is the area of photosynthetic surface produced by the individual plant over a period of interval of time and expressed in $cm^2$ $plant^{-1}$.

**ii. Leaf Area Index (LAI)**

Williams (1946) proposed the term, Leaf Area Index (LAI). It is the ratio of the leaf of the crop to the ground area over a period of interval of time. The value of LAI should be optimum at the maximum ground cover area at which crop canopy receives maximum solar radiation and hence, the TDMA will be high.

$$LAI = \frac{\text{Total leaf area of a plant}}{\text{Ground area occupied by the plant}}$$

**iii. Leaf Area Ratio (LAR)**

The term, Leaf Area Ratio (LAR) was suggested by Radford (1967), expresses the ratio between the area of leaf lamina to the total plant biomass or the LAR reflects the leafiness of a plant or amount of leaf area formed per unit of biomass and expressed in $cm^{-2}$ $g^{-1}$ of plant dry weight.

$$LAR = \frac{\text{Leaf area per plant}}{\text{Plant dry weight}}$$

iv. Leaf Weight Ratio (LWR)

It was coined by (Kvet *et al.,* 1971) Leaf weight ratio is expressed as the dry weight of leaves to whole plant dry weight and is expressed in $g\ g^{-1}$.

$$LWR = \frac{\text{Leaf dry weight}}{\text{Plant dry weight}}$$

**v. Leaf Area Duration (LAD)**

To correlate dry matter yield with LAI, Power *et al.* (1967) integrated the LAI with time and called as Leaf Area Duration. LAD takes into account, both the duration and extent of photosynthetic tissue of the crop canopy. The LAD is expressed in days.

$$LAD = \frac{L_1 + L_2}{2} \times (t_2 - t_1)$$

$L_1$ = LAI at the first stage

$L_2$ = LAI at the second stage, $(t_2 - t_1)$ = Time interval in days

**vi. Specific Leaf Area (SLA)**

Specific leaf area is a measure of the leaf area of the plant to leaf dry weight and expressed in $cm^2g^{-1}$ as proposed by Kvet *et al.* (1971).

$$SLA = \frac{\text{Leaf area}}{\text{Leaf weight}}$$

Hence, if the SLA is high, the photosynthesizing surface will be high. However no relationship with yield could be expected.

**vii. Specific Leaf Weight (SLW)**

It is a measure of leaf weight per unit leaf area. Hence, it is a ratio expressed as g $cm^{-2}$ and the term was suggested by Pearce *et al.* (1968). More SLW/unit leaf area indicates more biomass and a positive relationship with yield can be expected.

$$SLW = \frac{\text{Leaf weight}}{\text{Leaf area}}$$

**viii. Absolute Growth Rate (AGR)**

AGR is the function of amount of growing material present and is influenced by the environment. It gives Absolute values of biomass between two intervals. It is mainly used for a single plant or single plant organ e.g. Leaf growth, plant weight etc.

$$AGR = \frac{h_2 - h_1}{t_2 - t_1} \quad \text{cm day}^{-1}$$

Where, h1 and h2 are the plant height at $t_1$ and $t_2$ times respectively.

**ix. Net Assimilation Rate (NAR)**

The term, NAR was used by Williams (1946). NAR is defined as dry matter increment per unit leaf area or per unit leaf dry weight per unit of time. The NAR is a measure of the average photosynthetic efficiency of leaves in a crop community.

$$NAR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{(\log_e L_2 - \log_e L_1)}{(L_2 - L_1)}$$

Where, $W_1$and $W_2$ is dry weight of whole plant at time $t_1$ and $t_2$ respectively

$L_1$ and $L_2$ are leaf weights or leaf area at $t_1$ and $t_2$ respectively

$t_1 - t_2$ are time interval in days

NAR is expressed as the grams of dry weight increase per unit dry weight or area per unit time (g g $^{-1}$day$^{-1}$)

**x. Relative Growth Rate (RGR)**

The term was coined by Williams (1946). Relative Growth Rate (RGR) expresses the total plant dry weight increase in a time interval in relation to the initial weight or Dry matter increment per unit biomass per unit time or grams of dry weight increase per gram of dry weight and expressed as unit dry weight / unit dry weight / unit time (g g $^{-1}$day$^{-1}$)

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where, W1 and $W_2$ are whole plant dry weight at $t_1$ and $t_2$ respectively

$t_1$ and $t_2$ are time interval in days

**xi. Crop Growth Rate (CGR)**

The method was suggested by Watson (1956). The CGR explains the dry matter accumulated per unit land area per unit time (g m$^{-2}$ day$^{-1}$)

$$CGR = \frac{(W_2 - W_1)}{\rho\,(t_2 - t_1)}$$

Where, W1 and $W_2$ are whole plant dry weight at time $t_1 - t_2$ respectively

$\rho$ is the ground area on which $W_1$ and $W_2$ are recorded.

CGR of a species are usually closely related to interception of solar radiation

**xii. Total dry matter production (TDMP) and its distribution**

The TDMP is the biomass accumulated by the whole plant over a period of interval of time and its distribution (allocation) to different parts of the plant such as roots, stems, leaves and the economic parts which controls the sink potential.

**xiii. Translocation percentage (TP)**

The term translocation percentage indicates the quantum of photosynthates translocated from source (straw) to the grain (panicle/grains) from flowering to harvest.

$$TP = \frac{\text{Straw weight at flowering – straw weight at harvest}}{\text{Panicle weight at flowering – panicle weight at harvest}}$$

**xiv. Light extinction coefficient**

It is the ratio of light intercepted by crop between the top and bottom of crop canopy to the LAI.

$$K= \frac{\log_e \; I / I_o}{LAI}$$

Where, $I_o$ and I are the light intensity at top and bottom of a population with LAI

**xv. Light Transmission Ratio (LTR)**

It is expressed as the ratio of quantum of light intercepted by crop canopy at top to the bottom. Light intensity is expressed in K lux or W $m^{-2}$

$$LTR = I / I_o$$

Where, I : light intercepted at the bottom of the crop canopy

$I_o$: light intercepted at the top of the crop canopy

**xvi. Dry Matter Efficiency (DME)**

It is defined as the percent of dry matter accumulated in the grain from the total dry matter produced over the crop growth period.

$$DME = \frac{\text{Grain yield}}{\text{TDMP}} \times \frac{100}{\text{Duration of crop}}$$

**xvii. Unit area efficiency (UAE)**

It is expressed as the quantum of grain yield produced over a unit land area for a specified crop growth period.

$$UAE = \frac{\text{Grain yield}}{\text{Land area}} \times \frac{1}{\text{Duration of crop}}$$

**xviii) Harvest Index**

The harvest index is expressed as the percent ratio between the economic yield and total biological yield and was suggested by Nichiporovich (1951).

$$HI = \frac{\text{Economic yield}}{\text{Total biological yield}} \times 100$$