Critical Nutrient Concentration:

Critical Nutrient Concentration is the level of a nutrient below which crop yield, quality or performance is unsatisfactory. However it is difficult to choose a specific concentration.

For crops such as sugarbeet excessive concentration of N seriously affects the quality. So, CNC is maximum rather than a minimum consequently it is more realistic to use the critical nutrient range (CNR) which is defined as the range of nutrient concentration at a specified growth stage above which the crop is amply supplied and below which the crop is deficient.

Diagnosis and Recommendation Integrated System (DRIS) proposed by Beaufils (1973) which considers nutrient concentration ratios rather than individual elemental concentration for interpreting plant tissue composition. The DRIS approach measures the relative balance between nutrients by means of index values with negative values indicating insufficiencies and vice versa. DRIS reveals not only the limiting nutrient but also the order in which the nutrients are likely to become limiting. It is a comprehensive system which identifies all the nutritional factors limiting crop production and in doing so increases the chances of obtaining high crop yields by improving the fertilizer recommendations. Index values which measure how far particular nutrients in the leaf or plant is deviating from the optimum are used in the calibration to classify yield factors in the order of limiting importance.

To develop a DRIS for a given crop the following requirements must be met.

All factors suspected of having an effect on crop yield must be defined.

1. The relationship between these factors and yield must be defined.
2. Calibrated norms must be established.
3. Recommendations suited to particular set of conditions and based on correct and judicious use of these norms must be continuously refined.

Establishment of DRIS Norms:

Large number of sites is selected at random in order to represent the whole production area. At each site plants and soil samples are taken for all essential element analyses. The entire population of observation is divided into two sub populations (high and low yielders) on the basis of vigour, quality and yield. Each element in the plant is expressed in as many ways as possible. For eg: Nutrient ratios N/P, N/K or products NxP, NxK etc. Each form of expression which significantly discriminates between high and low yielding sub populations is retained as a useful diagnostic parameter. The mean values of all the sites for each of these forms of expression then constitute the diagnostic norms.

NPK requirement of the crop is diagnosed using DRIS chart. The chart is constructed of three axes for N/P, N/K and K/P represented with mean values of the sub populations of the high yielder. The concentric circle can be considered as confidence limits. Horizontal arrows (→) in the inner circle indicate the balance between nutrients. Diagonal arrows indicate ( ) a tendency to imbalance. The inner being set at $\pm$ 15% and outer at the mean $\pm$ 30% for each expression. Vertical (↓ ↑) arrows representing nutrient imbalance. The arrow notation can be replaced by DRIS indices.

Advantages:

1. The importance of nutritional balance is taken into account.
2. The norms for the elemental content can be universally applied.
3. Diagnosis can be made over wide ranges of stages.
4. The nutrients limiting the yield either through excess or insufficiency can be readily identified.

Indicator plants: Certain plants are very sensitive to deficiency of a specific plant nutrient and they produce specific symptoms which are different from other deficiency symptoms. Thus the deficiency of that element can easily be detected. The indicator plants are the following

Element	Deficiency indicator plant
N	Cauliflower, Cabbage
P	Rape seed
K	Potato
Ca	Cauliflower, Cabbage
Mg	Potato
Fe	Cauliflower, Cabbage, Potato
Na	Sugar beet
Mn	Sugarbeet, Oats, Potato
B	Sunflower

Biological methods of soil fertility evaluation:

For calibrating crop response, besides chemical soil test values other procedures are also available. They are

1. Mitscherlich pot culture method
2. The Jenny pot culture test
3. The Neubauer seedling method
4. The Stanford and Dement technique
5. Sunflower pot culture technique for boron
6. Sackett and Stewart technique (*Azotobacter* test for P_2O_5 and K_2O)
7. Mehlich technique for available K_2O
8. Mehlich *Cunninghamella* plaque method for phosphorus
9. The Mulder's *Aspergillus niger* test for copper and magnesium
10. A – value (tracer technique)

Microbiological methods are

1. **Sackett and Stewart technique**: Used to find out P_2O_5 and K_2O status in the soil judged by colonization of *Azotobacter* in the culture prepared from soil. Three containers having soil culture are used of which one portion is supplied with P_2O_5 another with K_2O and rest with both P_2O_5 and K_2O. The cultures are inoculated with *Azotobacter* and incubated for 72 hrs and growth of colony may be classified as under.

Class	Growth of the colony
Class I	Very deficient – None or few small pin head sized colonies are seen.
Class II	Moderately deficient – few colonies
Class III	Slightly deficient – The colonies on unfertilized cultures are equal in number and development.
Class IV	Not deficient – colonies on both fertilized and unfertilized plaques are equal in number and development.

2. Mehlich technique for available K_2O: A small amount of soil is taken in conical flasks in which appropriate nutrient solution is added and then it is inoculated with *Aspergillus niger* and incubated for four days. Weight of mycelial pad and its K_2O content are taken into account.

Critical limits for available K by using the *Aspergillus niger* method

Weight of 4 pads (g)	K_2O absorbed by *A niger* per 100 g soil (mg)	Degree of potassium deficiency
<1.4	<15	Very deficient
1.4 to 2.0	15 to 20	Moderate to slight deficiency
2.0	>20	Not deficient

3. Mehlich's *cunninghamella* plaque method for P: *Cunninghamella* is sensitive for P_2O_5 status. The soil is mixed with nutrient solution and paste is prepared which is spread in clay dish. Then inoculated with cunninghamella and allowed to incubate for 4-5 days. The diameter of the

mycelial growth is considered as an index for P status.

P – deficiency and mycelial growth

Diameter of colonies (mm)	Degree of P deficiency
<10	Very deficient
11-15	Moderately deficient
16-21	Slightly deficient
>22	Not deficient

4. Mulder's *aspergillus niger* test **for Cu and Mg** : Color of the mycelia and spores give an indication of either deficiency or sufficiency of Cu and Mg. For comparison, known standards are prepared as follows and their colors are compared with those on the unknown soil.

Ranges for Cu and Mg in Mulder's test

Cu in µg /g of air –dry soil	Deficiency degree	mg in µg/3 g of air – dry soil
< 0.4	Very deficient	< 50
1 – 1.5	Slightly deficient	50 - 100
>2.0	Not deficient	>100

Pot culture test:-

Besides plant analysis there are some biological tests which may be used to evaluate soil fertility.

1.**The Mitscherlich pot culture method**: In this method pots containing 2.72 kg soil are taken for growing oats as test crop. N, P and K are added in different combinations in these pots [N_o - one pot, P_o - three pots (NK), K_o- three pots (NP) and NPK - three pots)]. The crop is grown till maturity and percentage increase in yield is calculated by using Mitcherlich tables from rotation of given quantity of fertilizers over native fertility status (control).

2. The Jenny's pot culture test: Smaller pots consisting of 1.81 kg soil are used for growing

lettuce (*Lactuca sativa* longifolia) as test crops for 6 weeks. Following treatments are used in four replications.

Control	No Po Ko
Full fertilizer	N150 P150 K100
No nitrogen	N0 P150 K 100
No phosphorus	N150 P0 K100
No potash	N150 P150 K0

The percentage values are categorized as deficiency, probable deficiency and uncertain deficiency as mentioned below:

Jenny's values	**% yield**		
	Definite deficiency	**Probable deficiency**	**Uncertain deficiency**
N	20	20-50	51-70
P	20	20-50	51-65
K	70	70-75	76-80
S	66	66-76	77-83

3. The Neubauer's seedling method - In this technique, 100 seedlings of rye or oats are made to feed exhaustively on 100 g of soil mixed with 50 g of sand for 17 days in dishes of 11 cm and 7 cm depth. A blank without any soil also is taken. The total P_2O_5 and K_2O uptake is calculated and the blank value is deducted to obtain root soluble P_2O_5 and K_2O in 100 g of air dry soil. These values are designated as Neaubauer's numbers and expressed as mg/100 g of dry soil. The following Neaubauer limit values are used to determine the deficiency.

Neaubauer limit values mg/100 g soil

Nutrient	Barley	Oats	Rye	Wheat	Turnip	Potato	Sugarbeet
P_2O_5	6	6	5	5	7	6	6
K_2O	24	21	27	20	39	37	25

4. The Stanford and Dement technique: Round waxed cardboard cartons of about 100 g capacity with bottom removed which are nested in similar containers having intact bottom filled with 680 g of sand. The seeds of the test crop are sown about 1.25 cm deep. After growing the seedlings for 2 to 3 weeks, a carton containing the plants are nested in second carton holding 200 g of soil or soil mixed with fertilizers. The plant roots enter the second carton where these plants are allowed to feed for 3 to 5 days. Four plants of maize and 30 plants of wheat are maintained for the study. After 5 days the plant samples are taken to determine the nutrient content.

5. Sunflower pot culture technique for Boron: In this method 500 g soil is taken in small pot and 5 sunflower seedlings are allowed to grow. The soil is fertilized with a solution containing all the nutrients except B and deficiency of B is noticed and ranked.

Class	**Days after which B deficiency is noticed**
Marked deficiency	< 28
Moderate deficiency	28 – 36
Little or no deficiency	> 36

6. A value: By using radioactive isotopes, it has now become possible to calculate the available nutrients in the soil. Fried and Dean (1952) defined A-value as that amount of nutrients in soil which behave in a similar way as the applied fertilizer nutrient doses. This can be calculated by the formula.

$$A = B\left(\frac{1}{y} - 1\right)$$

Where.,

A = Available soil nutrient B = Amount of fertilizer nutrient applied. Y = The fraction of the nutrient derived from fertilizer contained in the plant.