NUTRITIONAL AND PHYSIOLOGICAL DISORDERS OF COTTON

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Nutritional problems and deficiency symptom in cotton depend on areas of production, which is directly or indirectly influenced both by soil and climate. With the introduction of new high yielding varieties and hybrids, rapid depletion of nutrients from soil has become a limiting factor in cotton production. Hence, the cotton growers have increased the rate of application of the major plant nutrients in the form of concentrated fertilizers every year, which have led to non-availability of secondary, and micronutrients in the soil. The amount of filler or carrier materials have been drastically reduced or eliminated in the fertilizers, thereby reducing the secondary and micronutrients substantially. Application of farmyard manure, which is a potent substitute for secondary and micronutrients besides enriching the soil health, is disappearing in modern cultivation. Therefore, the secondary and micronutrient requirements of cotton have to be supplemented along with fertilizer dose applied in soil or introduced into the plants through foliar application.

I. Nutritional deficiency symptoms in cotton:

The capacity of cotton plants to develop an extensive tap root system may partially account for the lack of widespread deficiency of micronutrients such as zinc, manganese, copper, boron, iron and molybdenum. Further more, the appearance of deficiency symptoms in cotton does not always imply that the nutrient in question is in short supply in the soil. Their solubility and availability can be influenced by one of the several factors like drought, water logging, climate conditions, pH of the soil, soil and plant health, antagonistic effect of other elements, etc.

a. Nitrogen Deficiency:

Nitrogen is usually concentrated in the growing points of the plant, which influences both rate, and extent of growth. As a component of chlorophyll, it is vital to carbohydrate metabolism. The severity of nitrogen deficiency symptom is usually greater in cotton growth under coarse textured soils where organic matter is low.

A pale yellowish green colour, coupled with reduction in leaf size is the most striking symptom of nitrogen deficiency in cotton. Eventually, the cells become disorganised accompanied by development of red pigments called anthocyanins. Nitrogen deficient plant is also characterized with little vegetative growth, lack of vigour coupled with stunted growth.

b. Phosphorus Deficiency:

Phosphorus is required in a lesser quantity than nitrogen. This nutrient simulates early and extensive development of the root system. The presence of this nutrient is essential for synthesis and break down of carbohydrates involved in energy transfer. It also promotes flowering and seed formation in cotton. Phosphorus when applied gets fixed in the soil particularly in low pH and becomes unavailable to the plant. Therefore, raising the soil pH of those soils to appropriate levels through application of lime is suggested to increase the efficiency of applied phosphorus.

Leaves of Phosphorus deficient plants remain dark green in colour with reduced leaf size. The deficiency symptom is first reflected in the lower or older leaves of cotton plant. The deepening of the green colour of the leaves progresses upward towards to the growing point to the extent phosphorus is deficient, suggesting that the nutrient moves to younger tissues as the supply diminishes. An extreme deficiency of phosphorus not only reduces the plant size, but also suffers from lack of secondary branches and reduction in boll number. It also leads to delay in blooming, fruiting and maturity of the bolls.

c. Potassium deficiency:

Potassium is the third major nutrient required for optimum production of cotton. Potassium is very much essential for movement of starch and sugars between different parts of the plant for normal cell division, growth and for nutralisation of organic acids. Also, a definite inter-relationship is maintained among potassium, calcium and sodium in tissues of cotton plant.

Lack of potassium results in a striking malnutrition symptom called 'cotton rust'. A yellowish white mottling of the foliage with characteristic change in leaf colour to light yellowish green spots appear between the veins. The tips of the leaf and margins break down and curl downwards. Finally, the whole leaf becomes reddish brown, dries and prematurely drops from the plant affecting the normal development of bolls, which remain small and immature. Many bolls fail to open altogether with poor quality fibre.

d. Calcium Deficiency:

Calcium is required within the plant cell to favourably influence the enzyme activity and also to cement the cell walls in the form of calcium pectate particularly in the growing points of roots and shoots where cell division and cell elongation take place. Cotton is known to be a calcium accumulator in order to synthesize organic acid compounds in the plant.

Calcium deficiency is generally manifested in early stage of the crop. The leaf petioles start bending and collapse later. These symptoms are seen in cotyledons as well as in true leaf stage of the crop.

e. Magnesium Deficiency:

Magnesium plays an important role in photosynthetic process and is a key element in the chlorophyll moiety and related enzymes. Deficiency symptoms appear in areas where fertilizers contain large amount of nitrate, sulphate or chloride ions. Where ammonium phosphate is used as the source of nitrogen, magnesium deficiency is at its minimum. This is due to the formation of magnesium ammonium phosphate, which prevents leaching of large quantities of magnesium from light textured soils.

The characteristics symptom of magnesium deficiency in cotton is the purplish red leaves with green veins. Deficiency symptoms first appear on the lower leaves and shed prematurely. Loss of leaves, with a corresponding reduction in photosynthetic activity results in poor yields.

f. Sulphur deficiency:

Comparatively, large amounts of sulphur are utilized by cotton plant. since, cotton seeds are rich source of protein and oil, sulphur becomes an important constituent. it is also associated in the formation of green pigment and sulphur containing amino acids. cotton soils generally gets replenished with sulphur through air, irrigation water and conventional fertilizer.

Cotton plants grown in sulphur deficient soil put forth yellowish leaves. New leaves deficient of sulphur become yellower as the growth progresses while the old leaves remain green because sulphur is not readily translocated to the growing points. In other aspects, symptoms of sulphur deficiency are similar to those which result from inadequate supply of nitrogen. Sulphur deficient plants are characteristically small, spindly with slender stalks.

g. Boron deficiency:

Although boron is required in trace amount, it plays a very important role in the reproductive process of the cotton plant. boron influences conversion of nitrogen and carbohydrates into more complex substances such as proteins and help in transfer of sugars within the plant. since boron occurs in mineral form as well as in the soil organic matter, deficiency can be expected in soils, which have low mineral level or low organic matter content.

Boron deficiency frequently appears first in the terminal growth of the cotton plant. The terminal bud often dies checking further vertical growth. Consequently, many lateral branches arise with shorter internodes giving a bushy appearance often referred to as 'rosette' condition. At low boron level, flower buds become chlorotic and the bracts flare open. Even surviving bolls are deformed presenting a flat-sided appearance. Excessive shedding of both squares and young bolls are a common feature.

h. Manganese deficiency:

Manganese is required in minute quantity for optimum production of cotton. It is associated with iron movement within the plant which in turn helps in the synthesis of chlorophyll. Manganese deficiency does not occur widely in field condition. However, where deficiency of manganese occurred particularly under high acid soil condition, the young leaves are affected initially.

They become yellowish or reddish grey in colour with green veins. Excess quantity of water soluble manganese in the soil will also lead to appearance of abnormal leaves. They become puckered, mottled, partially chlorotic and distorted in early stages with necrotic lesions subsequently appearing along the veins. As the plant approaches maturity, the affected leaves become slightly thickened and brittle.

i. Zinc deficiency:

Zinc deficiency has become a limiting factor in crop production now-a-days. Heavy use of lime on acid soils raises the pH with the formation of zinc hydroxide which has very low solubility. Also, excess application of phosphorous tends to form zinc phosphate, which decreases the availability of zinc to the plants.

Cotton seed germination appears to be normal under zinc deficient condition. However, soon after the true leaf appearance, a general bronzing and interveinal chlorosis appear. The leaves become thick and brittle with their margins cupped upwards. Squares and flowers that are formed tend to shed. With renewal of further growth, additional squares that are formed may mature into bolls depending on other factors.

II. Nutrient uptake and translocation in cotton

Cotton plant is perennial in nature and has been domesticated as an annual plant to overcome production and plant protection problems. However, the plant has a vigorous growth pattern drawing considerable amount of major and minor nutrient from the soil. Generally, nitrogen (N) and potassium (K) are taken up three folds than the phosphorous (P) and the 3:1:3 ratio of N P K is maintained.

Studies have shown that maximum uptake of nutrient was in tune with maximum dry matter production. The concentration of n and p decreased in leaves as bolls matured, whereas in stem and root, the n and p remained at constant level. Potassium contents of roots, stem and leaves decreased with boll development. Thus n and p were transported from leaves only, while potassium was transported from all vegetative parts to the developing bolls. The calcium and sulphate content in the leaves remained unchanged indicating the continuous absorption process. The magnesium content of the leaves decreased slightly during initial boll formation stage. Most of the nutrients were depleted from the leaves except calcium during maturity stage.

Studies revealed that nutrient uptake depends on the plant type traditional variety like mcu-1 with 160 days duration continued to be more vegetative for the first 100 days after sowing with utilization of NPK for vegetative growth. During boll formation the vegetative parts showed a rapid decline in the nutrient concentration. On the contrary in a short-branched compact variety PRS 72, the distribution pattern of nutrient appeared to be in a balanced way because of its less vegetative habit and tendency to fruit early. Even at maturity the nutrient content in the leaves and stem of PRS 72 were reduced appreciably whereas more nutrients remained unutilized in MCU-1. The study concluded that for producing the same quantity of yield, PRS 72, required less amount of nutrient (Table 1) suggesting that plant architecture and earliness influenced the nutrient uptake in cotton.

Table 1. Nutrients removed and yield of seed cotton (kg/ha)

Variety	N	P	K	Yield (kg/ha)
MCU-1	217	72	227	3017
PRS 72	130	44	136	3151

III. Physiological disorders in cotton

Cotton is commercially grown as a Kharif crop during the month of August-September. During the crop growth, cotton is exposed to unpredicted vagaries of nature and is prone to many physiological disorders like bud and boll shedding, leaf reddening and excessive vegetative growth etc. leading to poor yields.

a. Bud and Boll Shedding

Flowering in cotton commences from the month of October – November coinciding the North East monsoon. During this period, the crop suffers from insufficient light due to cloudy days with intermittent rainfall for several days. Consequently, the photosynthetic rate of the plant decreases and development of flowers and young bolls are retarded for want of proper nutrition. Besides, due to insufficient light, production of key hormones like auxin in the leaf is also limited inducing a hormonal imbalance in the plant. Under such circumstances, release of ethylene is triggered with formation of abscission layer in the fruiting zone leading to bud or boll shedding. Only one-third of the total flowers produced contribute to final yield. The remaining two-third are shed at various intervals either due to insect-pest or due to environmental reasons like continuous drought or water logging, high humidity in the atmosphere, continuous rainfall affecting the pollination process etc. Studies have shown that application of NAA and DAP to irrigated crop of MCU-5 (Table-2) reduced the buds and bolls shed and increased yield significantly. Similar effect was observed on rainfed cotton (Table 3).

Table 2 : Effect of NAA and DAP on yield in irrigated cotton MCU-5

Treatment	Buds and bolls shed per plant	Yield (Kg/ha)
Control	24	1507
NAA 20 ppm	20	1743
DAP 1%	18	1820
NAA alternated with DAP	16	1970

Table 3: Effect of NAA and DAP on yield of rainfed cotton var. 1412

Treatment	Buds and bolls shed	Bolls retained	Boll weight (g)	Yield (kg/ha)
Control	6.1	4.0	2.5	183
NAA 20 ppm	3.4	7.4	2.8	345
DAP 1%	3.2	7.1	2.9	422
NAA alternated with DAP	2.5	8.5	3.0	556

Sometimes, shedding may be due to other factors like reduced availability of nitrogen or phosphorous. Under such conditions, foliar application of 1% urea or 2% diammonium phosphate (dap) during flowering at 10-15 days interval was found beneficial.

b. Leaf Reddening:

It is generally observed 90 days after sowing particularly where cotton is grown in red or laterite soils. The leaf initially starts yellowing and finally the entire leaf turns red leaving the midrib and other vascular regions green. Deficiency of nutrient, high temperature during the day coupled with low temperature at night, water stress or water logging are some of the important factors attributed to leaf reddening. Generally, by 100th day the cotton crop is heavily laden with developing bolls. During this phase, the demand for assimilate by the developing bolls is high and the plant is not in a position to meet the demands of the sink. Subsequently, the nitrogen concentration in the leaf is depleted below the critical level in the leaf and uptake of magnesium from the soil is antagonized leading to nitrogen induced magnesium deficiency in the plant (Table 4).

Table 4. Nitrogen and magnesium content of leaves in hybrid cotton

Cultivar	Type of leaves	Nitrogen (%)	Mahgnesium (Mg O)%
H4	Green healthy leaves	2.667	1.249
H4	Advanced leaf reddening	1.083	1.243
Varalaxmi	Green healthy leaves	2.833	0.820
Varalaxmi	Early leaf reddening	1.450	0.480
Varalaxmi	Advanced leaf reddening	1.165	0.554

Gradually, the chlorophyll moiety of the cell is broken down and cells become disorganized with the formation of anthocyanin pigments giving a red appearance to the leaf. Foliar spray of 2% DAP once in 10 days was found to be economical and effective to correct the disorder. In places where the disorder is severe 0.5% magnesium sulphate should also be added along with the spray schedule.

c. Excessive Vegetative Growth:

In cotton, it is established that only the lower two-third portion of the plant contributes to 90% of the yield and the upper one-third either remains immature or with poor quality fibre. Hence detopping or trimming the top 10cm of the plant at 100-120 days after sowing will arrest the excessive vegetative growth and allow more penetration of light to the lower side of the plant. This also reduces lodging and facilitates easy control of pests and diseases, besides increasing boll retention and boll size.

d. Control Measures:

Thus an integrated approach to reduce the physiological disorders in cotton is through foliar application of naphthalene acetic (20ppm) + 1% of diammonium phosphate and 1% of murate of potash which are commercially available in the market. The sprays should be given from the flowering phase of the crop at 10-15 days interval until harvest followed by detopping the upper 10cm of the plant at 100-120 days after sowing. The following precautions should be taken.

- The sprays should be only in the evening hours
- Diammonium phosphate should be prepared and left overnight to extract maximum nutrient and the extract should be filtered before spray.
- 0.1 percent teepol can be added as surfactant
- Insecticides can also be mixed with DAP extract if necessary to reduce the cost of labour
- Timely spray will help better performance of the crop