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PHYSIOLOGICAL DISORDERS IN COTTON

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PHYSIOLOGICAL DISORDERS IN COTTON

PREFACE

Cotton, known as the "King of fibres" occupies a unique position in Indian Agriculture. Its cultivation dates back to centuries. Presently, this crop is grown under varying agro-climatic conditions. It is noticed with distress that innumerable abiotic and biotic factors affect cotton, thus limiting productivity. Physiological disorders appear as a consequence of nutritional / hormonal imbalances and vagaries in environmental conditions. A proper understanding of these disorders will be useful while taking up appropriate control measures.

Studies on physiology and biochemistry of abiotic disorders in terms of processes and metabolism, nutritional deficiency/toxicity and their symptoms will provide plethora of scientific information for further refinement of management strategies. Further, implementation of WTO accord pertaining to trade and economy will lead to stiff global competition and we have to guard ourselves from such onslaughts on our economy. As cotton researchers, our prime objective should be to develop appropriate technologies and provide an impetus for enhanced production and quality through scientific research and technology adaptation in cotton cultivation.

The technical bulletin "Physiological disorders in Cotton" contains comprehensive and useful information on various disorders with suitable illustrations and management options. I am confident that this bulletin will be of immense use to all those concerned directly or indirectly with cotton research, development and cultivation.

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1. INTRODUCTION

Cotton is an important cash crop grown in India. It occupies an area of about 8.5 million hectares and is grown in both irrigated and rainfed tracts. More than 70 per cent of the total cropped area is under rainfed condition and the lint yield per hectare (375 Kg) is low as compared to the world average (650 kg). Under rainfed condition, cotton production mainly depends on the timing and amount of rain, which is unique in every year. The duration of cotton crop is quite long owing to its indeterminate growth habit. Therefore, both genotype and environment have conspicuous effects on growth and development.

In cotton, the growth profile has initial lag phase followed by an exponential phase coinciding with squaring, flowering and boll development. At flowering stage, there is a high demand for moisture, nutrients and photosynthates by the developing squares and bolls. The limitation in assimilate supply coupled with the production of hormones such as ABA and ethylene imposes restriction on the plant to retain only few bolls which mature as open bolls. In this context, it is pertinent to know how abiotic and biotic factors affect the canopy leaf area available for capturing sunlight for the purpose of photosynthesis (Fig.1 a & 1 b). Depending on the genotypes grown and the time and magnitude of occurrence of abiotic stresses such as drought, waterlogging, cloudiness, salinity, high or low temperature, nutrient deficiency etc., the vegetative and reproductive parts of the cotton plant develop various physiological disorders that either directly or indirectly affect the productivity.

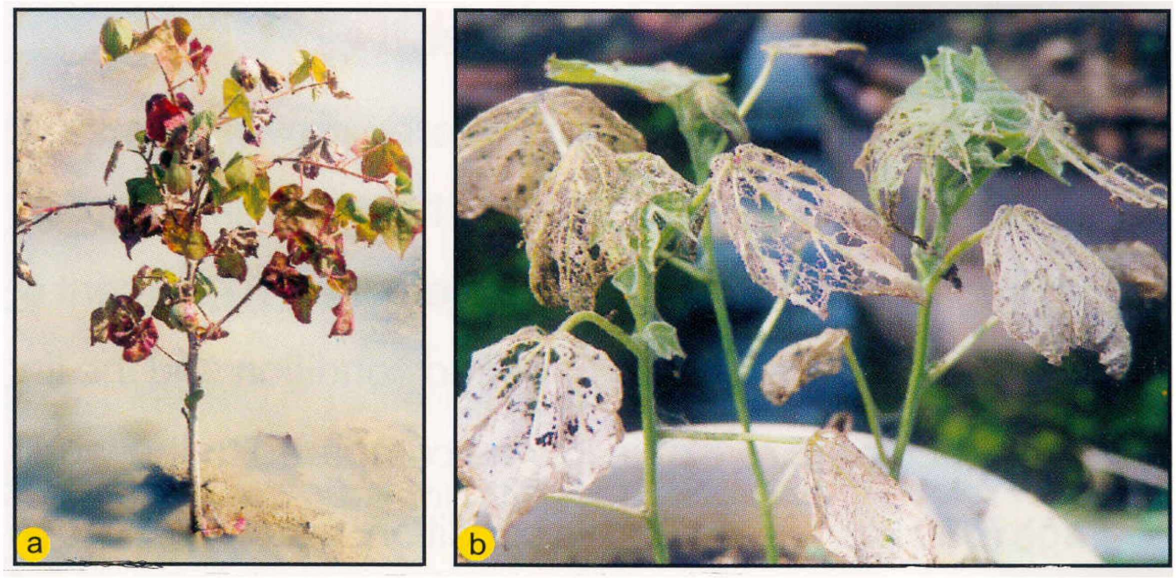

Fig.1. Photosynthetic leaf area affected by a) abiotic and b) biotic stress factors

In view of the economic importance of this crop as well as the recent advances in scientific applications such as biotechnology/nanotechnology, it is imperative to know in detail about the various physiological disorders so as to effectively manage the crop from sowing to harvest. Some of the commonly observed physiological disorders in cotton along with their symptoms and the options available to minimize their impact are presented in this bulletin.

2. PHYSIOLOGICAL DISORDERS

Physiological disorders appear in cotton as a reflex of plant response to environmental stresses, nutritional imbalances and chemical factors. Their effect on productivity depends upon the crop growth stage, intensity of incidence and loss of reproductive parts during ontogeny.

However, there is a distinct difference between plant adaptation to harsh growing environments and physiological disorders. The various adaptive traits in plants as a response to the stress environment such as production of small leaves during drought and lenticel formation under waterlogged condition are not considered as physiological disorders.

Some of the commonly occurring physiological disorders in cotton are-

- **Leaf reddening**
- **Parawilt/New wilt**
- **Leaf drying / burn**
- **Bud and Boll drying**
- **Bad boll opening**
- **Crazy top**
- **Crinkle leaf**
- **Effect of 2,4-D**
- **Bud and Boll shedding:** A natural phenomenon, may be considered as physiological disorder if the shedding is unusually prolonged and intense due to disturbances in source-sink relationship.
- **Mineral Nutrients deficiency/toxicity:** Though nutrient deficiency/toxicity is not disorder in strict terms, it is worthwhile to know various symptoms because they affect the plant metabolism and cause various physiological disorders.

2.1. LEAF REDDENING

Leaf reddening in cotton is also known as red leaf disease (lal patti). This disorder is an outcome of interaction of location, variety, environmental condition and nitrogen supply. In general, some of the hirsutum varieties and a few inter and intra specific tetraploid hybrids are sensitive and vulnerable to this malady. Apperance of red leaf symptom is primarily, due to the accumulation of anthocyanin pigment. Leaf reddening may occur at any growth stage of the crop. However, it is quite often confused with the reddening of leaves caused by sucking pest damage at early growth stages. At grand growth phase (flowering and boll development) any hindrance in the assimilate production, translocation and distribution intensifies the leaf reddening effect. The factors affecting ideal source-sink relationship promote leaf reddening and symptoms are prolific in nature under extreme stress situations.

Symptoms

Leaf reddening is initially seen in the mature leaves and gradually spreads throughout the canopy (Fig. 2 a). To begin with, leaf margin turns yellow and later red pigmentation is formed on the whole leaf area (Fig. 2b). In due course of time the leaf becomes dry and subsequently prone to shedding.

Fig. 2a. Leaf reddening in the plant canopy

Fig.2b. Intensity of leaf reddening as compared to normal leaf

Causes

The reddening appears in the plants due to various reasons-

Lowered nitrogen level in the leaves (below the critical limit) due to -

- Low availability in the soil
- Impaired uptake under water deficit and waterlogging conditions
- Diversion of N to the developing bolls
- Synchronized boll development and high boll demand
- Desiccation caused by high wind velocity

Anthocyanin (red) pigmentation due to -

- Abrupt changes or drop in night temperature (below 15° C)
- Nitrogen deficiency
- Magnesium deficiency
- Chlorophyll degradation

From Table 1, it is clear that reddened leaves had less nitrogen and magnesium contents. It is observed that nitrogen stressed leaves accumulated carbohydrates due to the derailment in its conversion process. As a result, there is an increase in C/N ratio. Similarly, these leaves had predominant accumulation of anthocyanin content.

Table 1. Effect of leaf reddening on leaf nitrogen, carbohydrate, magnesium and anthocyanin contents in MCU 5 and CBS 156 cotton cultivars

Cultivar	Total N (%)	Total CHO (%)	Magnesium (g/100g leaf)	Anthocyanin (ppm congored equivalent)
Leaf (Normal)				
MCU5	3.8	7.5	1.6	4.0
CBS 156	3.6	7.5	1.2	7.0
Leaf (Reddened)				
MCU 5	3.4	10.0	1.4	6.0
CBS 156	2.5	12.0	1.1	8.0

Management

- Adjustment of sowing time for enabling the crop to skip over the adverse environmental condition during boll development stage.
- One or two sprays of urea (1 %) at appropriate times.
- Application of magnesium sulphate (0.5%)
- Adequate drainage to avoid waterlogging of the fields
- Leaf reddening incidence due to sucking pests may be overcome by spraying

recommended insecticides

- ❖ Boll load management
- ❖ Supply of adequate nutrients during flowering and boll development particularly in hybrids
- ❖ Timely inter-culture and weeding operations and other agronomic practices
- ❖ Avoidance of susceptible cultivars
- ❖ Adequate irrigation if available
- ❖ Adoption of crop rotation and growing of intercrop to maintain the soil health and nutritional status

2.2. PARAWILT/NEW WILT

In early 1980s a wilt like malady referred to as new wilt or parawilt caused considerable concern amongst cotton growers across the country. It is also called as Adilabad wilt or sudden wilt. Unlike pathogenic wilt, which occurs in groups of plants in fields, this malady was noticed to be sporadic (random) in distribution (Fig. 3). Hence, it is difficult to quantify the incidence and the yield loss. Detailed investigation on isolation, distribution pattern and pathogen transmission proved that fungi, bacteria, virus and nematodes were not involved in this malady. The etiology of parawilt could not be proved till recently mainly because of its random occurrence and inability to simulate the wilt under artificial conditions.

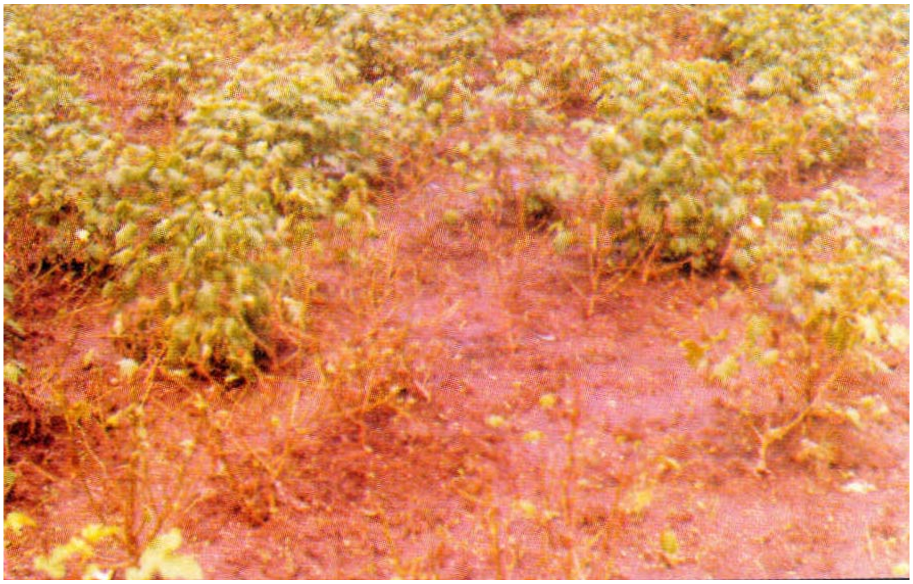

Fig. 3. Field view of parawilt affected cotton plants

Symptoms

The wilt may develop either slow or quick. The incidence is particularly high in plants with large canopy and heavy boll load (Fig. 4a and 4b). In the affected plants, leaves show wilt like drooping, become chlorotic and turn bronze or red followed by drying. Premature abscission of leaves and fruiting parts may occur. Leaves lose turgidity due to enhanced transpiration. Squares and young bolls are shed and immature bolls are forcefully opened. Wilted plants show development of anthocyanin pigment. Most of the wilted plants gradually recover and produce new flushes, however their contribution to yield is negligible.

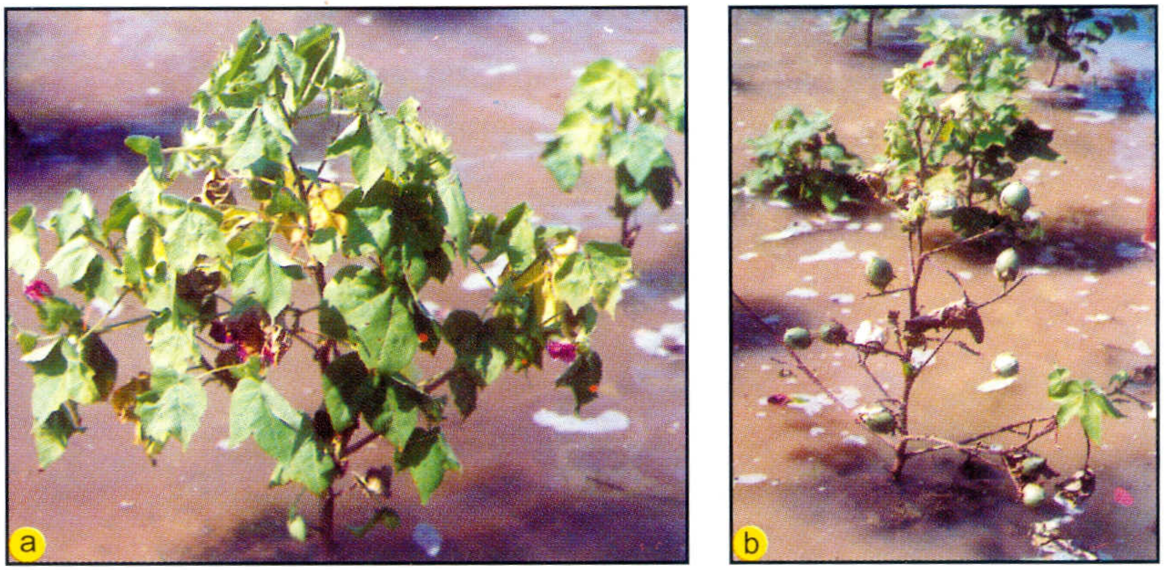

Fig. 4. Parawilt affected plants with a) large canopy and b) heavy boll load

Causes

- Cultivation of susceptible varieties/hybrids
- Higher demand for nutrients and moisture
- Prolonged dry spell with high temperature and sunlight followed by soil saturation due to heavy downpour or irrigation
- Wilt incidence is high in heavy clayey and deep soils
- Incidence is more in ill drained soils as compared to well drained soils

At CICR Nagpur, studies were conducted to create the wilt symptoms under artificial condition and the causes of wilt were elucidated. As presented in the flow chart (Fig.5), plants with large canopy and heavy boll load are more prone to wilting. These plants exhibited high photosynthesis and transpiration rate (Table 2). Consequently, for the conversion of photosynthates into proteins and other macromolecules these plants required higher uptake of nutrients which is an active process and inhibited under anaerobic (water-logged) condition. As a result of the feedback inhibition of root respiration, the root system gets degenerated in wilted plants. Damage to the roots caused higher resistance to the mass flow of water through the roots. This coupled with higher transpiration in wilted plants due to their insensitive stomata caused parawilt in cotton.

Management

- Planting of wilt tolerant genotypes: Wilting was not seen in *G.arboreum* and *G.herbaceum* genotypes. Hybrids like JKHY 1, DCH 32, NHH 44 are wilt sensitive.

Varieties such as LRA 5166, LRK 516 (Anjali), SRT1, MCU 5 VT, AKH 4, G 27 and Jayadhar are relatively tolerant to wilt

- ❖ Provision of adequate drainage to avoid waterlogging of the fields
- ❖ Irrigation if available may be provided during grand growth phase to avoid prolonged exposure of plants to dry condition
- ❖ Excessive use of farm yard manure and fertilizers may be avoided in heavy soils
- ❖ Curtail excessive vegetative growth

Table 2. Temporal measurement of photosynthesis and transpiration in control and waterlogged plants under field condition

(Values in parenthesis are standard deviation)

Days after Waterlogging	Transpiration (moles/m²/sec)			Photosynthesis (umoles/m²/sec)		
	Control	Waterlogged		Control	Waterlogged	
		Wilt tolerant	Wilt susceptible		Wilt tolerant	Wilt susceptible
1	7.2	7.3	8.1	26.5	25.5	29.0
	(0.09)	(0.34)	(0.78)	(0.71)	(0.71)	(1.41)
2	7.0	6.9	3.5	27.0	27.0	11.5
	(0.21)	(0.25)	(0.12)	(1.41)	(1.41)	(0.71)
4	7.4	6.3	0.04	27.5	21.0	0.3
	(0.13)	(0.46)	(0.01)	(0.71)	(1.41)	(0.42)
9	7.2	6.2	-	27.0	15.0	-
	(0.15)	(0.56)		(1.41)	(0.83)	
13	7.0	5.7	-	25.5	15.5	-
	(0.46)	(0.34)		(2.12)	(0.71)	
28	7.3	6.1	-	27.0	14.5	-
	(0.51)	(0.29)		(1.41)	(2.12)	

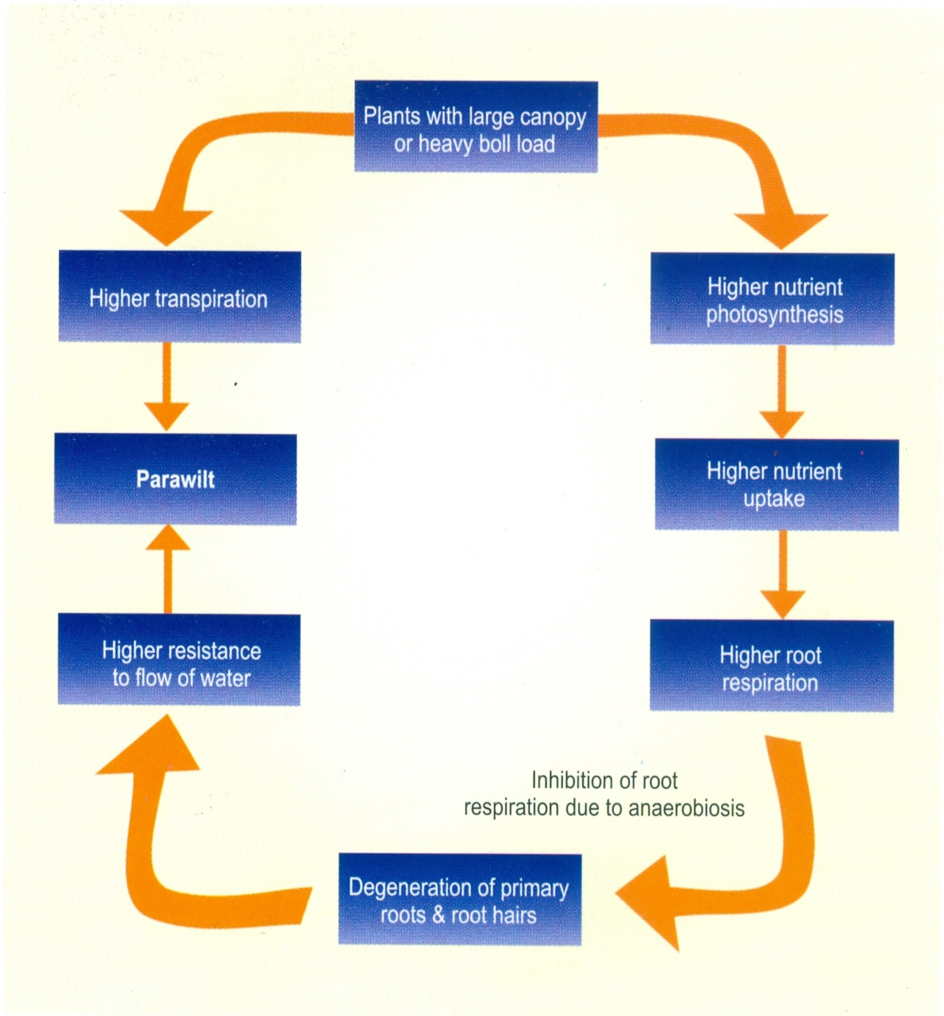

Fig. 5. Flow chart showing the possible involvement of various processes in causing parawilt

2.3. LEAF DRYING / BURN

Leaf drying is of common occurrence in Asiatic cotton. It is generally seen during boll development with the prevalence of prolonged high day and night temperatures coupled with bright sunshine hours. Moisture limitations at flowering and boll development augment the incidence.

Symptoms

To begin with, the young leaves at the top of the canopy show necrosis near leaf margins and become dry. Under prolonged conditions, the necrosis gradually moves inward (Fig. 6). The dried leaves are shed.

Fig.6. Leaf drying in *arboreum*

Causes

Specific reasons for the leaf drying has not been assigned. However, it is possible that the higher transpiration loss of water due to the characteristic deep root system of Asiatic cotton as noticed in moisture stress studies could have caused desiccation. It is more common in problematic soils. Under extreme conditions, the squares and developing bolls also become vulnerable and start drying up.

Management

- Selection of heat tolerant genotypes
- Protective irrigation may be given if irrigation facility is available at boll development stage
- Application of soil mulch to reduce the evaporative loss of water from the soil surface

2.4. BUD AND BOLL DRYING

This disorder is very much restricted to a few varieties, with short fruiting branches and cluster boll habit. However, the disorder may occur in other varieties under extreme environmental aberrations.

Symptoms

The developing buds and bolls start drying up slowly (Fig. 7a & 7b). The dried buds and bolls become black in color and immature bolls may crack. Dried fruiting bodies are seldom retained on the plant. Lint and seed qualities are affected.

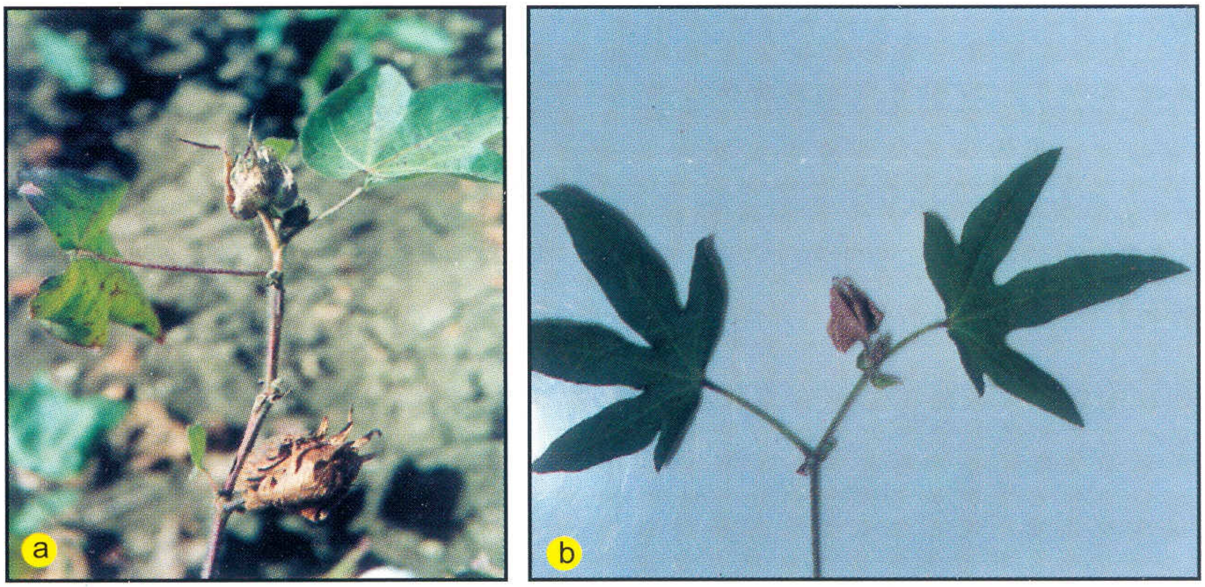

Fig. 7. a) Bud and boll drying in *hirsutum* and b) bud drying in *arboreum*

Causes

Studies indicated that non-availability of requisite photo- assimilates to the developing bolls led to boll drying. Starch accumulates due to the impaired amylase (starch hydrolysing enzyme) activity in the leaves of these plants. Occurrence of this disorder is more common in soils with salinity/alkalinity and also in light sandy soils with low nitrogen status. High temperature and dry weather during flowering enhanced this effect.

Management

- Selection of suitable genotypes: Variation is seen between the species and varieties for boll drying. *G.hirsutum* genotypes are more prone to boll drying
- Adjustment of sowing dates
- Timely correction of nutrient deficiency (particularly N)
- Frequent irrigation in saline soils

2.5. BAD BOLL OPENING

Bad boll opening is also called as Tirak. The problem is basically concerned with premature and improper cracking of bolls, instead of normal fluffy opening (Fig 8).

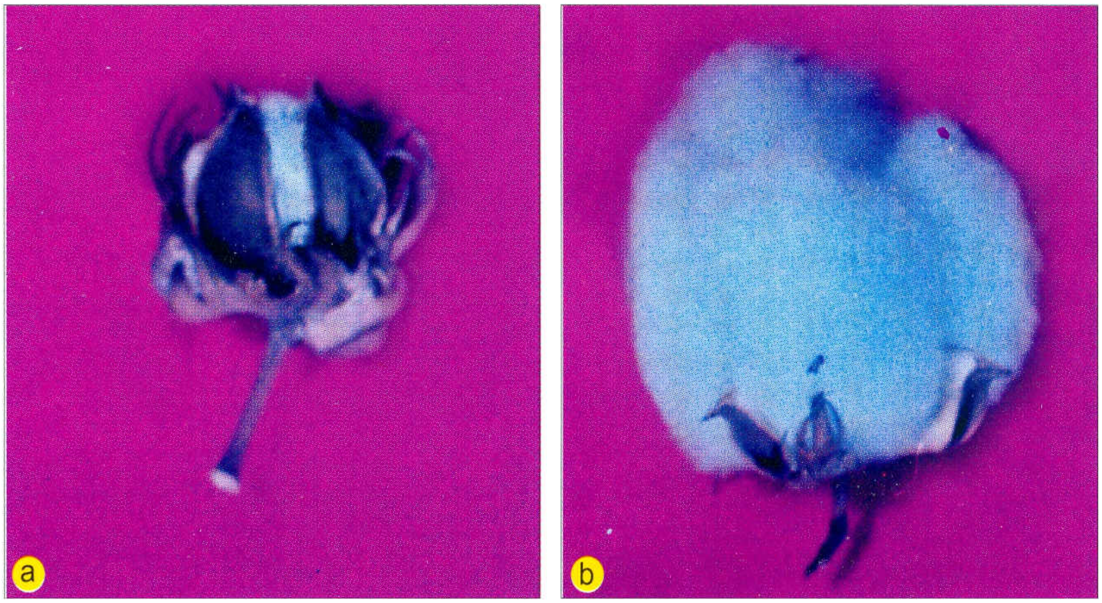

Fig. 8. Improper boll opening-a) bad boll and b) normal boll

Symptoms

Initially the leaves turn yellow and subsequently become red. The capsule wall of the bolls become tight and do not open completely. The affected bolls may turn black in color with time. The fibre as well as seed quality are affected.

Causes

- Soil with subsoil salinity
- Light sandy soil
- Nitrogen deficiency
- Prevalence of low humidity, warm and dry weather during fruiting period
- Low moisture and nutrient availability during boll formation

Management

- Adjusting sowing dates so that the boll formation stage is not affected by any environmental stress or nutritional deficiency
- Appropriate nitrogen management at critical growth stages
- Frequent irrigations to reduce effect of subsoil salinity/ alkalinity
- Timely application of nitrogen in light sandy soil
- Use of growth retardant to check excessive vegetative growth

2.6. CRAZY TOP

Crazy top depicts the uneven growth and development, particularly in the meristematic region. The occurrence is mostly restricted to calcareous soils and often noticed in areas of irregular irrigation practices.

Symptoms

Abnormal branching and fruiting in the upper canopy leading to crazy appearance of the plant. Typical symptoms include distortion of plant parts, leaves become small, rounded, cupped and thickened and shedding of fruiting forms.

Causes

- Common in calcareous soils
- Irregular irrigation practices or uneven trends in the available water

Management

- Timely irrigation if facilities are available
- Application of sufficient organic matter
- Adequate nutrient supply

2.7. CRINKLE LEAF

This disorder is not of common occurrence. Sometimes, when the available nutrient contents in the soil are too high or under specific conditions some of the nutrients are taken up in large quantity, these nutrients in turn may cause toxicity to the plants. Manganese is one such element which is taken up in large quantity under waterlogged condition or in acidic soils leading to development of chlorosis and crinkled leaf symptoms (Fig. 9).

Symptoms

Mottling, chlorosis and distortion of leaves. Initially the symptoms are seen in the young leaves and gradually spreads to the lower canopy.

Fig.9 Crinkle leaf symptom in the top canopy

Causes

- Acidic soils
- Calcium deficiency
- Manganese toxicity

Management

- Application of gypsum to neutralize manganese toxicity and to overcome calcium deficiency
- Adequate drainage to avoid waterlogging

2.8. EFFECT OF 2, 4-D

2, 4-Dichlorophenoxy acetic acid (2,4-D) is used as a selective herbicide in field crops. Cotton is very sensitive to the growth regulator/herbicide 2, 4-D. Even a small quantity is sufficient to bring about phyto- toxic effects. It is often noticed that a drift of 2, 4-D spray due to wind action from the adjoining areas/fields may cause 2, 4-D syndrome in cotton.

Symptoms

The symptoms include abnormal changes in morpho frame of the plants. Leaves droop and become epinastic.

The leaves, floral parts and the bracts are malformed. The leaves become narrow and elongated with prominent veins. The flowers become tubular with elongated floral parts (Fig. 10). It was noticed that 2, 4-D (5 ppm spray) at flowering led to stem elongation. However, the phyto-toxic effects and abnormal changes in leaf and floral parts are accompanied by partial to full loss of apical dominance. As a result, lateral growth arising from the lower nodal positions give bushy appearance to the plant.

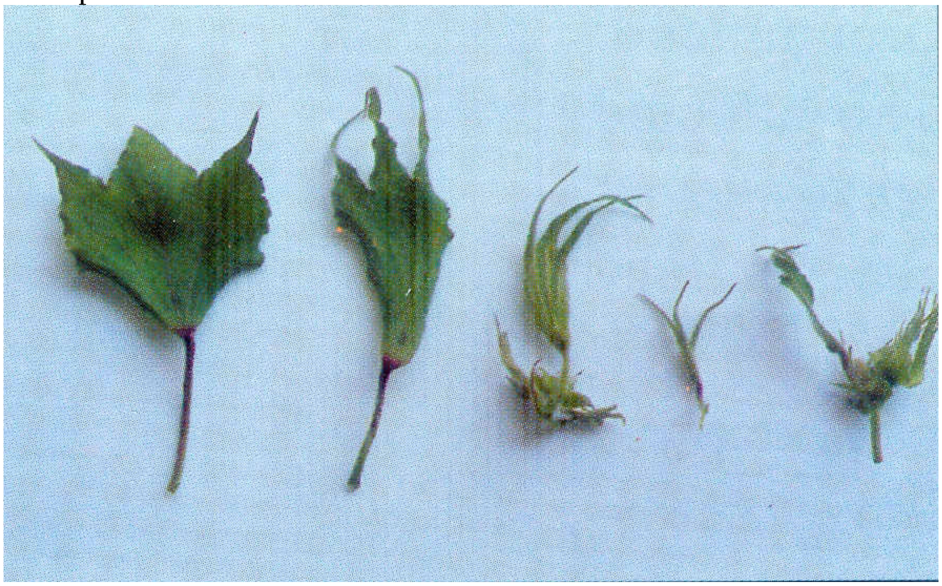

Fig.10. Malformation of leaf and floral parts due to 2, 4-D effect

In the affected morpho- frame, the terminal leaves are mostly cup shaped and are leathery in appearance (Fig.11). The petioles of the affected leaves often turn pinkish or purplish in color. The squares show predominant yellowing and are in the process of shedding. The symptoms appear quickly under optimum growing conditions and the appearance of the symptoms is delayed when the growth process is slow. Apparently, plants are more sensitive to 2, 4-D at early growth stages, whereas in older plants the symptoms appear slow and are not well pronounced. The affected leaves do not recover fully while, the newly emerging leaves become normal with passage of time.

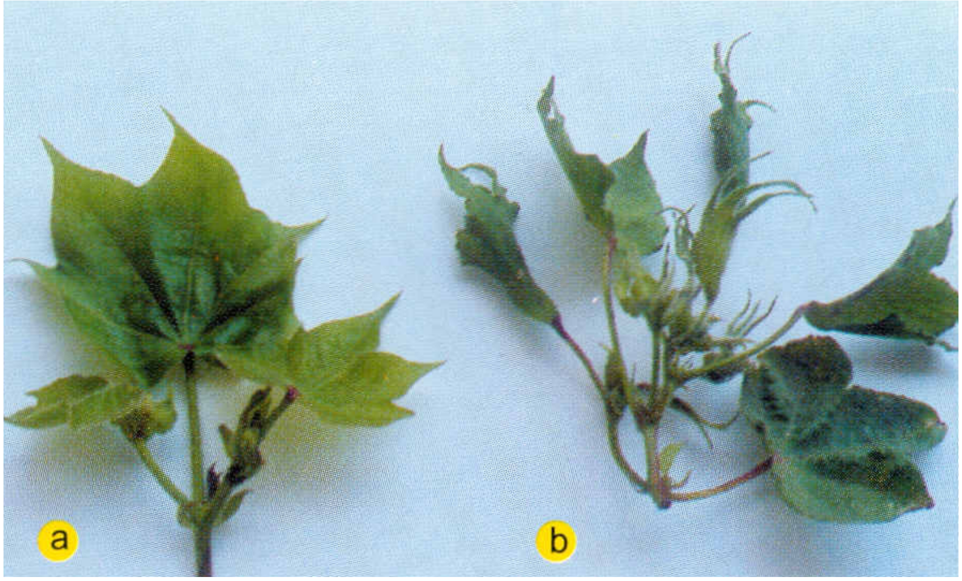

Fig. 11. Apical meristematic region of a) normal and b) 2, 4-D affected plant

Foliar application of 2, 4-D (5 to 50 ppm range) on 70 day old plants brought out symptoms such as epinasty and drooping of meristamatic leaves at lower concentration, while at higher concentration the bottom leaves also showed epinastic symptoms and the meristematic region dried up.

The photosynthesis, transpiration and stomatal conductance of the 2, 4-D affected leaves were drastically reduced (Table 3).

Table 3. Photosynthesis, transpiration and stomatal conductance of 2, 4 D affected plants

Treatment	Transpiration (m mole m^{-2} s^{-1})	Stomatal conductance(m mole m^{-2} s^{-1})	Photosynthesis (u mole m^{-2} s^{-1})
Control	5.63	380	19.7
2, 4-D (5 ppm)	4.32	289	5.9

Management

- Avoid using the sprayer used to spray 2, 4-D in other crops in cotton. Otherwise, sprayer should be thoroughly washed to prevent any contamination
- Water spray can be given to minimize the effect of 2, 4-D
- Urea spray (1 %) is advisable for quick production of new flushes
- Foliar application of calcium carbonate (1.5%) or Gibberellic acid (50 ppm) led to the recovery of plants from the effects of low concentration of 2, 4-D

2.9. BUD AND BOLL SHEDDING

Cotton plants produce numerous squares and only few bolls are retained. Abscission of fruiting forms (squares and bolls) is a major determinant of the number of bolls harvested. Shedding of fruiting forms occurs with the commencement of squaring. The young squares are indiscriminately and continuously shed and the shedding magnitude is higher under harsh growing environments. It is often noticed that fruiting parts which are about to abscise, turn yellow in color due to limitation of nutrients/hormonal imbalances (Fig. 12). Bolls beyond 10-12 day old are seldom shed. Among the various canopy architectures, compact varieties are less prone to shedding.

The process of shedding commences due to the formation of abscission layer. Heavy boll load under conditions of optimum canopy production leads to inter and intra competition amongst the developing organs for current photosynthates.This condition may increase shedding of fruiting forms, if the demand is not immediately met with. Several environmental and biological (physiological and entomological) events have a direct bearing on boll retention. Environmental conditions which influence the shedding of fruiting parts in cotton are low light, high temperature, drought, waterlogging, cloudy weather etc. These factors affect assimilate translocation to the developing reproductive sinks leading to abscission. Other major causes of abscission are lack of pollination due to very high temperature or rain falling on the open flower and insects that feed or oviposit on the fruiting forms.

Fig. 12. Square at initial stage of its abscission

Table 4. Correlation between morpho-physiological characters and abscission of fruiting parts

Morpho-physiological characters	Physiological shedding
Plant height	0.129
Leaf area	0.132
Total dry matter production	0.064
Leaf thickness	0.137
No. of nodes	- 0.160
Specific leaf area	0.296
Specific leaf weight	- 0.277
Relative water content	0.015
Stomatal resistance	- 0.673**
Transpiration rate	0.538**
Flower production	0.532**

From Table 4 it is clear that significant correlation existed between morpho-physiological traits and physiological shedding of squares and bolls. Flower production and transpiration had a significant positive correlation while, stomatal resistance had a significant negative correlation with physiological shedding. It implies that under favorable stomatal conductance large amount of current photosynthates are available to the developing sinks, which enabled the plants to produce more flowers. Intensive flowering and the subsequent boll load on the other hand, would have limited assimilate distribution to the competitive sinks thus resulting in enhanced physiological shedding. Negative correlation with stomatal resistance further signifies the importance of stomatal conductance for effective photosynthesis. Though, significant correlation existed between flower production and physiological shedding, it may not remain so at all circumstances due to abiotic/ biotic disruptive trends.

A date of planting experiment with two cultivars viz. AKH 081 and LRA 5166 grown in pots with three distinct dates viz., 15th of June, July and August at CICR, Nagpur indicated that delay in planting dates led to decrease in the production of nodes, leaves and squares per plant while there was a significant increase in the shedding of fruiting parts. As a consequence, the yield realization was reduced with late plantings.

Table 5. Effect of planting dates on physiological shedding of fruiting forms

Cultivar	Date of Planting	Nodes per plant	Leaves per plant	Squares per plant	Total physiological shedding (%)
AKH 081	15 June	10.7	25.4	18.0	35.4
	15 July	10.5	23.0	13.6	41.7
	15August	9.8	14.7	13.9	53.0
LRA 5166	15 June	12.9	25.9	28.4	23.1
	15 July	12.7	22.6	23.1	37.9
	15 August	10.9	13.7	16.5	39.4

The shedding pattern considerably varies depending upon the genotypes, growing conditions, abiotic and biotic factors, soil nutritional status etc. Under rainfed condition, there is a pronounced shedding due to physiological causes. Prolonged drought condition accompanied by high temperature will accelerate the shedding process. In the Central zone, early formed squares are exposed to low light conditions whereas developing bolls are mostly subjected to drought environment. These two abiotic factors are responsible for augmentation of physiological shedding of fruiting forms in cotton, particularly under rainfed condition.

In a field experiment conducted at CICR, Nagpur, developing squares were regularly tagged for about two months period and the shed fruiting parts were collected periodically in a few chosen cultivars to determine the extent of production and shedding of fruiting forms (Table 6). Considerable variation in square production and shedding of fruiting parts was evident.

Table 6. Square production and physiological bud and boll shedding in few cultivars

Cultivars	No. of squares formed /plant	Physiological Squares	Shedding (%) Bolls
AKH 081	43.8	8.4	29.1
Bikaneri Nerma	47.7	12.0	35.2
LRA 5166	91.2	5.7	14.5

Management

- Proper crop care- in terms of adequate nutrient supply, avoidance of rank growth, spraying of nutrients and growth regulators at critical stages and protection of crop from insect pests.
- Studies conducted at CICR, Nagpur indicated that fruiting parts produced during the month of September contribute to more than 50% of bolls retained at harvest. Hence, care of cotton crop needs more emphasis at such crucial periods to improve retention of bolls
- It is seen that an auto-regulatory system regulates the shedding of fruiting parts in cotton.

During periods of severe pest damage, the shedding due to physiological causes becomes low as a compensatory effect. Application of Naphthalene Acetic Acid (NAA) 10 to 20 ppm alone or alternated with 1 to 2 % di-ammonium phosphate (DAP) during early flowering stage once or twice as per the requirement was found to be effective in reducing square and boll shedding due to physiological causes. It is advisable to apply the hormonal and nutritive correctives preferably in the morning /evening hours to obtain the best results

- In irrigated and high input management conditions some of the genotypes tend to produce excessive vegetative growth. Rank growth may cause mutual shading of leaves within the canopy. Under such conditions use of growth retardants, for ego Mepiequate chloride at 50 ppm reduced the vegetative growth, enhanced water use efficiency and enabled retention of more fruiting forms
- Field should be well drained to avoid the occurrence of waterlogging
- Sowing date should be adjusted in such a way that peak flowering would not coincide with rains, high temperature or drought

3. MINERAL NUTRIENTS DEFICIENCY / TOXICITY

Cotton crop due to its intrinsically perennial habit has a vigorous growth profile and absorbs selective amounts of major and micronutrients from the soil. Followed by the initial 30 to 40 day lag phase, the exponential phase coinciding with squaring, flowering and boll development has the maximum requirement of nutrients. Nitrogen and potassium taken up are thrice the amount of phosphorus. Sulphur is also found to be an essential nutrient for cotton. Amongst the micronutrients considerable work has been done on the requirement of boron, and zinc in cotton. If these nutrients are not available in the soil, plants are unable to take up as per the need and develop deficiency symptoms.

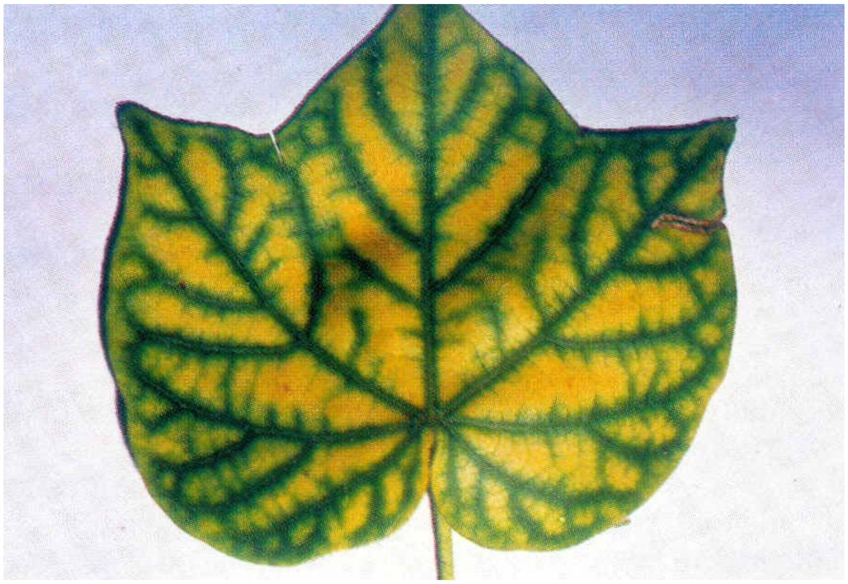

Fig. 13. Typical inter-veinal chlorosis symptom of cotton leaf

Some of the deficiency symptoms of major and micronutrients are presented in Table 7, and a typical interveinal chlosis symptom is shown in Fig.13. Deficiency symptoms can be overcome by the timely application of appropriate nutrient elements. Among the macro elements, nitrogen and its deficiency symptoms are common under field condition. With regard to potassium, Central Indian soils are rich in potassium and therefore plants do not readily show deficiency symptoms.

Table. 7. Major and micronutrients, their critical concentration and deficiency symptoms in cotton.

Nutrient	Critical concentration*	Deficiency symptoms
Nitrogen (N)	2.0 - 2.5%	Leaves light green, lower leaves turn yellow. Under acute deficiency leaves become dry and brown. Plants are stunted
Phosphorus (P)	0.35 - 0.5 %	Leaves dark green, older leaves small and often develop red and purple pigmentations
Potassium (K)	2.0 - 3.0 %	Also known as potash hunger or rust or yellow leaf blight. Older leaves dark green, necrotic spots not involving veins, curling and scorching of leaf margin. Shedding of leaves, improper opening of bolls, seed and lint are affected
Calcium (Ca)	2.5 - 3.0 %	Interveinal chlorosis of young leaves. Extremely stunted growth due to necrosis of meristematic tissues
Magnesium (Mg)	0.4 - 0.8 %	Leaves mottled or chlorotic, necrotic spots on lower leaves. Under acute condition leaves are reddened
Sulphur (S)	1.5 - 1.8 %	Young leaves with veins and tissues between veins light green in color
Iron (Fe)	200 - 300 ppm	Young leaves turn chlorotic, principal veins typically green, stalks short and slender
Manganese (Mn)	100 -140 ppm	Symptoms similar to nitrogen deficiency. Leaves become uniformly light green, followed by yellowing. Veins remain green without necrotic spots. In waterlogged soils and under acidic condition often Mn becomes toxic
Zinc (Zn)	30 - 80 ppm	Terminal buds start dying following the appearance of distortions at tips or bases of young leaves. Necrotic spots involving veins. Plant height, node number and square production are reduced. The deficiency results in increased root exudation of amino acids, sugars and phenolic compounds
Boron (B)	>0.8 ppm	New flowers are distorted and there may be excessive shedding of squares. The sepals around the bolls may fail to harden with low levels of available B. An acute shortage results in death of terminal growth and consequently, the lateral buds may develop chlorotic leaves. Chlorophyll content, photosynthates and CO_2

		assimilate transport are affected
Molybdinum (Mo)	-	Symptoms resemble N deficiency and more common late in the growing season. As the plant grows the older leaves show a pronounced effect. First symptoms appear in the form of small spots of dead tissue usually at tips, between veins and more marked at leaf margins
Copper (Cu)	2 - 20 ppm	One of the peculiar symptoms of Cu deficiency is chlorosis, with or without spots of dead tissue scattered all over the leaf. Chlorosis is less marked near the veins, but affected areas eventually turn brown. Cu deficiency increased root weight and reduces stem weight and yield of reproductive organs

(* Source: Critical concentrations and related information are collected from the available literature)

4. FUTURE LINE OF WORK

Intensive cotton cultivation is envisaged in the coming years to enhance the productivity so as to make it more competitive in terms of price and quality in the international market. This in addition to the changing global environment such as EI Nino effect, ozone depletion etc. may further lead to the onset of some more unknown physiological disorders.

- **Cultivation of high yielding hybrids and transgenic cotton:** The agronomic input requirements of high yielding varieties and hybrids including the transgenics are likely to be much higher as compared to the traditional varieties. Since these hybrids/ transgenics are likely to produce and retain more number of bolls per plant, they need optimum growing conditions. Any deviations in the ambient environment may have deleterious effect on both production and quality aspects. The indiscriminate use of irrigation water may alter the soil chemical properties, which in turn may bring in adverse effects.
- **Pollutants and chemicals:** In our country, cotton crop alone consumes nearly 50 per cent of the total pesticide used in agricultural crops. New chemicals/molecules and their combinations are regularly released to check pest incidence without an in-depth assessment of their effects on plant processes, metabolism and secondary metabolites accumulation. Introduction and indiscriminate use of various forms of new chemicals may also affect the soil microbial composition and impair the uptake of nutrients. Similarly, excessive use of fertilizers may lead to soil salinity, alkalinity and acidity. Ingress of sea water (Tsunami) may enhance salinity. These factors in all possibility may promote development of physiological disorders hitherto unknown.
- **Greenhouse effect:** The rapid industrialization and consequent deforestation activities led to emission of certain gases such as CO_2, CO, N_2O etc. Over the years, CO_2 level in the atmosphere is gradually increasing and it is predicted that by the end of this century it may become double. Since, cotton is a C_3 crop, experiments showed a transient benefit in growth and productivity of cotton with enhanced CO_2 concentration. However, the associated rise in temperature with the greenhouse effect might offset this benefit because the concommitant increase in temperature may enhance both dark and photorespiration.

Leaf scorching observed in a few genotypes at present may become more prominent across genotypes as a result of rise in global temperature. Boll setting may also get affected at high temperature regimes.

The depletion of ozone layer in the earth's atmosphere due to the release of CFC (Clorofluoro carbon), may lead to higher transmittance/incidence of short wave UV-B radiation that is harmful to the growth and development of crops leading to development of physiological disorders and low productivity.

Thus, there is further scope to unravel the causes and mechanisms involved in the manifestation of physiological disorders as well as those likely to emerge in the near future in a perspective and holistic approach. In this context, research linkages are to be established in the frontier arena pertaining to physiological, biochemical and molecular approaches.

Suggested for further reading:

Dastur, A. D. et.,al (1960). Cotton in India: A Monograph. Indian. Central Cotton Committee, Bombay.

Bhatt, J. G. (1996). Cotton Physiology. Indian Society for Cotton Improvement, Bombay.

Dhopte, A. M. (2001). Leaf reddening in cotton. Kalyani Publishers, New Delhi

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