Eggplant little-leaf disease was first observed in Coimbatore in 1939 by Thomas and Krishnaswamy. It is a yellows type of disease. Approximately 300 diseases belonging to this group have been reported (Varma and Rajamannar, 1989), although their number in economically important plants is small. These diseases not only result in reduced yield but also adversely affect the quality of the product and even lead to premature death of plants. Nearly 20% of coconut palms died in one year in Caucun region of Mexico due to lethal yellowing (McCoy et al., 1982). In India, a number of plants suffer from yellows type of diseases which brings about a considerable loss in the crop yield as worked out for sandal spike (Nayar, 1974; Raychoudhuri and Varma, 1980); Pyrus malus (Nagaich and Vasistha, 1965), grassy shoot of sugarcane (Prakasham, 1973), Sessamum phyllody (Marimuthu et al., 1973), coconut root wilt (Solomon et al., 1983), eggplant little-leaf (Mall and Sheikh, 1977) and Chrysanthemum distortion virus (Singh, 1970). Several yellows-type of diseases have been reported from our country. Out of these, the eggplant little-leaf is most widely distributed. This disease has been reported from Delhi (Vasudeva, 1956), Maharashtra (Verma et al., 1965), Punjab (Bindra et al., 1972), Madhya Pradesh (Mall and Sheikh, 1977), Orissa (Kar et al., 1982),
Kerala (Anjaneyulu and Ramakrishnan, 1973), TamilNadu (Srinivasan and Chelliah, 1977) and West Bengal (Chakrabarty and Choudhury, 1972). The disease has also been reported from some other tropical and sub-tropical countries, those are Japan (Shikata et al., 1969), Malaysia (Singh, 1973), and Sri Lanka (Newton and Peires, 1953).

This disease is characterised by virescence, gradual reduction of the size of leaves and flowers, floral phyllody, shortening of internodes, extensive branching with the branches bearing little leaves of near normal pigmentation, stunting and failure of fruition (Padmanabhan et al., 1973). The symptoms were grouped by Anjaneyulu and Ramakrishnan (1973) as follows.

a. Smalling of leaves,
b. Proliferation of axillary shoots and buds,
c. Stunting of shoot and root growth, and
d. Virescence and floral phyllody.

The mycoplasmal etiology of the disease is well documented. Several workers have reported the presence of MLOs in the phloem tissues of naturally infected plants and their absence within healthy (Namba et al., 1981, Mitra and Gupta, 1984, Petzold and Marwitz, 1984, Singh, 1988). The MLOs are localised in the sieve tubes of the phloem tissue in form of filamentous and budding forms (Higgs and Sinha, 1978).
The yellows type of diseases were earlier considered to be viral diseases due to their graft transmissibility, filterability of the causal organisms through bacteria proof filters and virus like vector transmission. Doi et al., (1967) first demonstrated association of diseases in Japan. This was soon followed by several reports on the association of mycoplasma like organisms (MLOs) with many other yellows type of diseases from various parts of the world (Anjaneyulu and Ramakrishnan, 1969; Kar, 1983; Varma and Rajamannar, 1989). These diseases are generally graft transmissible (Ploaie et al., 1980; Raju and Munippa, 1981; Rao et al., 1983; Chen et al., 1984; Padmanabhan, 1984; Yuan, 1984; Harding and Teakle, 1985). They spread in nature through leaf hoppers as vectors (Heinze, 1959; Sommereyns, 1967; Ishihara, 1969).

A good direct evidence for the association of MLO with yellows type of diseases is the observation of MLOs in the phloem sieve elements in ultra thin sections of diseased tissue by electron microscopy (Cousin et al., 1970; Maramorosch et al., 1970; Nayar, 1971; Varma et al., 1969; Varma and Rajamannar, 1989). Lee and Davis (1983) demonstrated through dark field microscopy the presence of MLOs in sieve tubes of plants after separating the phloem by partial digestion with enzymes. Recently MLOs responsible for diseases in plants have been isolated from their hosts and purified. These include MLOs associated
with clover phyllody (Clark et al., 1983; Sinha and Madhosingh, 1980), aster yellows (Jiang and Chen, 1987; Sinha and Madhosingh, 1980), peach-X disease (Sinha and Chiykowski, 1980) and peanut witches broom (Hull et al., 1970).

Lin and Chen (1985) partially purified the aster yellows MLOs from salivary glands and heads of the transmissive leaf hoppers. Sinha and Madhosingh (1980) studied the composition and concentration of various amino acids of mycoplasma cells 'purified' from clover phyllody and aster yellows affected plants. In 1986 da Rocha et al., reported partial purification of four different MLOs associated with potato witches broom, clover proliferation, eastern aster yellows and western aster yellows from infected Catharanthus roseus.

All the diseases caused by MLOs are susceptible to tetracycline therapy which brings about reversal of symptoms. Purple top roll and witches broom of potato were effectively controlled with antibiotics, antiamoebin, chloramphenicol and tetracycline (Giri and Nagaich, 1972). Coconut trees showing lethal yellowing suppressed their symptoms when infected directly with 100ppm oxytetracycline hydrochloride by gravity or 50ppm tetracycline hydrochloride under pressure (Mc Coy, 1972). The oxytetracyclin hydrochloride produced rapid remission in comparison with tetracycline hydrochloride. Several
workers reported the response of little-leaf diseased eggplant to tetracycline derivatives. Anjaneylu and Ramakrishnan (1969) reported that treated plants showed symptoms at a later stage than the plants untreated with tetracyclines. They screened 16 antibiotics and 4 sulphonamides for their efficacy against little-leaf disease of eggplant and found application of 10-50 ppm of tetracycline or 50-100 ppm of chloramphenicol significantly prolonged the incubation period (Anjaneyulu and Ramakrishnan, 1972).

Bindra et al. (1972) showed that diseased eggplants resumed normal growth 30 days after the last spray when sprayed with 500 ppm tetracycline hydrochloride or alternate days for 27 days. The spray of the tetracycline at lower concentrations were not effective in bringing about symptoms reversal. Varma et al. (1975) found that out of 6 antibiotics tested by them, Garramycin and Penicillin had no effect on the disease. Application of both pre and post inoculation sprays were more effective than the post inoculation spray only. Complete reversal of symptoms occurred when 1000 ppm of tetracycline was applied by girdle method. (Verma and Dubey, 1976).

Application of some insecticides have also been reported for successful control of eggplant little leaf. The disease incidence is reduced by weekly spray of folidol for 11 weeks (Vasudeva, 1956) and application of
phorate at 1 kg/hectar at the time of transplanting followed by 6 sprays of 0.05% malathion, 0.15% carbaryl at 15 days interval (Sohi et al., 1974). Mote and Joi (1977) reported that application of phorate and aldicarb at 1 kg/hectare followed by a spray of tetracycline hydrochloride and monocrotophos brought complete reversal of symptoms.

LITTLE-LEAF AND ALLIED DISEASES FROM OTHER PLANTS IN INDIA

Little leaf and allied diseases in several other plants have been reported from India besides the brinjal little-leaf mentioned earlier.

Little-leaf disease in Catharanthus roseus was reported by Anjaneyulu and Ramakrishnan, 1969; Kar, 1982. Hull et al., (1970) reported occurrence of little-leaf disease in Duranta plumeiri, Eclipta prostata, Justicia gendarussa and Linarea sp. with possible mycoplasmal etiology. Varma and Singh (1975) found the little-leaf of Justicia was graft transmissible. Subsequently presence of MLO in the phloem of diseased plant was demonstrated (Phatak et al., 1975). Mycoplasmal etiology was also demonstrated for the little leaf of Petunia and Phyllanthus (Ghosh et al., 1975).

Nayar and Anatapadmanabha (1977) found natural occurrence of little-leaf disease on Barleria mysorensis,
Eucalyptus citridore, E. grandis, Dichrostachys cinerea and considered these as collateral hosts of sandal spike disease.

Other plant diseases occurring in India with reported mycoplasmal etiology include phylophy of Calendula (Mali and Vyanjane, 1977), Cicer arietinum (Kandaswami and Natarajan, 1974), Cannabis sativa (Phatak et al., 1975), Sesamum indicum (Cousin et al., 1970), Brassica campestris, Tagetes erecta (Corbett et al., 1972), witch's broom of Acalypha indica (Nayar, 1971), Dodonea viscosa (Padmanabhan et al., 1973), Mirabilis jalapa (Ghosh et al., 1974, 1975), Zizyphus oenoplea (Hull et al., 1970), citrus greening disease (Leafleche and Bove, 1970), Sodhi et al., 1973), Grassy shoot of sugarcane (Corbett et al., 1972), Rishi et al., 1973) and bunchy top of banana (Nayar, 1971).

Mycoplasmal etiology of the greening disease in orange tree was first reported by Lafleche and Bove (1970). Presence of MLO in the phloem tissues of diseased shoots was demonstrated by Lafleche and Bauvat (1972). Ghosh et al., (1971), isolated and cultivated MLO from the midribs of infected leaves. Vectors artificially infected with that culture could transmit the disease to healthy seedlings (Nariani et al., 1973). Remission of symptoms occurred when diseased plants were treated with tetracyclines (Martinez et al., 1970; Capoor and Thirumalachari, 1973; Nariani et al., 1971; Peterson and
Sesamum phyllody was first reported by Pal and Pushkaranth (1935). It is common in Sesamum growing areas. The typical symptoms of the disease include vein cleaning of leaves and stimulation of axillary buds. Advancement of disease leads to extreme reduction of the leaves and internodes with virescence and phyllody of flowers (Vasudeva and Sahambi, 1955, 1957).

The MLO incited yellow dwarf disease of rice has been reported in some parts of Orissa, Bihar, West Bengal, Andhra Pradesh and Delhi (Raychoudhuri et al., 1967). The disease is characterised by pronounced stunting with chlorotic leaves reduction in flowering and fruition leading ultimately to sterility. This disease is reported to be transmitted in nature by green leaf hopper Nephotettix virescence which is also the vector for tungro virus disease of rice (Mitra and John, 1973).

ECOLOGY OF MYCOPLASMA INFECTED DISEASES

The effects of environmental factors on plant diseases have been reported by Colhoun (1973). It was evident from the review that ecology of mycoplasma like diseases have received much less attention compared to other plant diseases.
One of the most well studied diseases having mycoplasmal etiology is the Clover phyllody (Vasudeva and Sahambi, 1955). The pathogen is transmitted in nature by vector *Eucelis plebejus*. The leaf hoppers have a 30 days latent period after an acquisition feeding of 20 days before being infective (Cousin et al., 1968; Frazier and Posnette, 1957). Hampton (1972) observed that many MLOs are transmitted, only after a latent period in the vector and long term experiments are needed to study the characteristics of the relationship between the pathogen and its vector leafhoppers. (Cousin et al., 1968, Maramorosch, 1963). Maramorosch in 1967, described transmission of aster yellows with *Macrosteles fascifrons*. Corn stunt disease is transmitted by *Dalbulus elimatus* (Granados et al., 1968). Iyenger and Grifth (1941) reported *Jassus indicus* as a natural vector of sandal spike disease. They obtained a positive correlation between the increase in vector population and disease spread in nature. Vasudeva and Sahambi (1955) reported *Deltacephalous* sp. as the natural vector of Sessamum phyllody disease and obtained a definite correlation between vector population and disease spread.

The Brinjal little leaf disease is reported to be spread in nature by *Hishimonus phycitis*, Dist. (Syn; *Eutettix phycitis = Cestius phycitis*) (Bindra and Sohi, 1968, 1969; Mitra and Majumdar 1977; Mote and Joi, 1977) and *Amrasca biguttula biguttula* (Syn *Amphoasca*
Konai (1984) conducted experiments on eggplant little leaf disease transmission employing both *H. phycitis* and *A. devastans*. He found that of the two, only *H. phycitis* did transmit the disease. The leafhoppers *H. phycitis* is also reported to transmit *Catharanthus* little leaf disease (Kar and Panda, 1990). Mayee and Kaur (1975) obtained a positive correlation between vector population and natural incidence of eggplant little-leaf disease. Similar results were also obtained by Srinivasan and Chelliah, (1977).

Dodder transmission of some mycoplasma disease have also been reported. Those are, peach-x (Carling and Milliken, 1977), Eggplant little-leaf (Kar *et al.*, 1982), *Periwinkle* little leaf (Kar and Panda, 1990).

Many mycoplasma diseases have wide host range. (Anjaneyulu and Ramakrishnan, (1973) found that eggplant little-leaf pathogen infected 60 species of plants belonging to 13 genera distributed in 5 families. The families with maximum susceptible hosts was Solanaceae followed by *Compositae*, *Leguminosae*, *Apocynaceae*, *Papaveraceae* and *Pedaliaceae*. A wide host range has also been reported for disease like Tomato big bud (Hill, 1943). Sandal spike (Nayar, 1973; Nayar and Anantapadmanabha, 1977) and Sessamum phyllody (Sahambi, 1970).
Temperature is a major factor out of the various physical factors affecting the course of mycoplasma incited disease development. Rise in temperature affects the disease development adversely and has been used for cure of eggplant little—leaf disease (Anjaneyulu and Ramakrishnan, 1973) Citrus greening (Nariani et al., 1973) and grassy shoot of sugarcane (Edision, 1977). Hollings (1965) prepared, while reviewing the subject, a list of 86 mosaic type virus diseases which were inactivated around about 40°C. He generalised the tentative statement that most "yellows" type and proliferation types of viruses and many mechanically transmissible viruses with isometric particles can be eliminated by heat treatment. Some of the viruses listed by him and now known as mycoplasma diseases are aster yellows, tomato stolbur, potato and parastolbur, Crimean yellows, Clover dwarf, Cranberry false blossom, potato witch broom, mulberry dwarf, Clover wound tumour, delphinium yellows, strawberry green petal, peach rosette, peach yellows, strawberry witches broom and sweet potato yellow dwarf.

Physiological Changes Under Pathogenesis

The group of pathogens falling under mycoplasma like organisms infecting plants was established rather recently. Therefore much evidence is not available on the physiological disorders associated with MLO infections. In the list of plant virus names,
issued by the Common Wealth Mycological Institute (Martyn, 1968) most of the diseases with which mycoplasma like bodies have been associated are listed as a group of viruses infecting seed plants transmitted by leafhoppers and for which there is no information available concerning the physical and chemical properties of the virus particle.

Majority of these, previously called yellows dwarf and stunt virus disorders, have now been established as mycoplasma diseases. Therefore, in the following review, of physiological diseases a general account is given with greater emphasis on 'yellow dwarf' and 'stunt' disease wherever possible.

Photosynthesis is directly affected in the plants under pathogenesis. The quantity of chlorophyll is reduced or the breakdown of chloroplast occur. In contrast there is no change in the healthy plant (Peterson and Mc Kinney, 1938; Roberts et al., 1952; Nambiar and Ramkrishnan, 1969; Singh and Srivastva, 1970 Sridhar et al., 1976; Kabi et al., 1970; Nanda et al., 1979; Panda and Kar, 1991. The breakdown of Chloroplast is accompanied by the loss of chlorophyll in which the lamellar structure gets disrupted (Abbot and Sass, 1945; Pares and Bertus, 1978). Viruses can also disrupt the grana because, that they primarily parasitize the chloroplasts cannot be
ruled out. Mathews (1973) found TYMV to be primarily a parasite of the chloroplast.

The mycoplasma like disorders associated with the aster yellows and peach-X disease alters the chlorophyll content of infected Catharanthus roseus L. leaves. The reduction in total chlorophyll is quantitative for both disorders but there is preferential reduction of chlorophyll a with respect to chlorophyll b in peach-X disease (Carling, 1975; Carling and Milliken, 1977; Panda and Kar, 1991).

In certain virus infections some of the enzymatic processes of photosynthesis are impaired. The Hill reaction activity of sugarbeet chloroplasts infected with Sugar beet yellows (Spikes and Stout, 1955) and the Hill reaction and Photophosphorylation in chloroplast isolated from TMV infected plants (Zaitlin and Jagendorf, 1960) are impaired due to virus infection. Reduction in the Hill reaction rate is also observed for chloroplasts of bean infected with - YBMV (Kabí et al., 1979) and papaya infected with PMV( Kar et al., 1979) Kar et al., (1979) found that the reduction in Hill reaction rate was not correlated with the reduction of chlorophyll, apparently indicating that other component of the photosynthetic apparatus are affected prior to the chlorophyll degradation. Hall and Loomis (1972 b) showed that in sugarbeets infected with beet yellows, the infected leaves had greater resistance
to the exchange of gases, a fact which accounted for most of the photosynthetic reduction (Hull et al., 1972). In sugarcane infected with sugarcane mosaic virus, though there was an overall reduction in the net photosynthetic rate per unit chlorophyll was higher in severely affected strains (Irvine, 1972). Panopoulus et al., (1972) found that the amount of $^{14}$O$_2$ fixed in curly top virus infected leaves was 40% lower than the healthy, with a strong retention of recent assimilates in the soluble forms. Carbohydrate metabolism is greatly affected by pathogenesis. Holmes (1931) observed that tobacco plant infected with TMV failed both to form and metabolic starch at normal rate. Accumulation of storage and soluble carbohydrate (Orlob Arny, 1961; Choudhury and Mukhopadhyaya, 1974; Singh and Srivastava, 1974) or their paucity (Kabi et al., 1979; Kar et al., 1979) has been reported for several virus like disorders. In some others, however the levels remain relatively unchanged (Sridhar et al., 1972; 1976).

Initial increase in the sugar content followed by its subsequent decrease has been reported for eggplant suffering from little-leaf disease (Panda and Kar 1991). Different workers have reported different levels of carbohydrates even for the same pathogen-host combinations. Mandhar and Garg (1972) reported an increase in sugar, decrease in starch and an overall decrease in total carbohydrate contents of virus infected groundnut
leaves. Later, Singh and Srivastava (1974) working with the
same host pathogen combination observed accumulation of
starch and decreased content of sugar under pathogenesis.
Kabi et al., (1979) in yellow bean mosaic infected papaya
leaves from that the amylase activity was greatly reduced
under infection. Kar et al., (1979) suggested that the
alter status of starch hydrolysing enzyme might be the
major cause of dearrangement in the starch metabolism
under pathogenesis.

One of the most general phenomena in physiology
of diseased plants, is an increase in respiratory rate
(Allen, 1953; Daly, 1976; Farakas and Kiraly, 1955;
Millard and Scott, 1956; Merret and Bayley, 1969). In virus
diseased plants an enhancement of respiration occurs only in
advanced stages of systemic infection (Bawden, 1959;
Yarwood, 1953). In the diseased plant the total nitrogen
content is decreased due to the relative decrease in
protein as compared with healthy plant(Henke, 1956).
In Dolichos yellow mosaic virus infected bean leaves
Singh et al., (1976) found lower levels of total nitrogen,
protein nitrogen and total free amino acids as compared
to healthy plants. However, this trend was reversed in the
older leaves.

There are several reports on the effect of
infection on the concentration of amino acids in the
leaves of virus infected plants. An increase in the amino
acid content was observed in various hosts showing virescence (Skofenko and Kushinirenko, 1970, Kar et al., 1980). The amino acid content, however, remain unchanged (Tosic, 1971) in some cases and in some other cases soluble nitrogen content decreased (Sommer, 1957). Johri et al., (1979) in chlorotic stunt infected periwinkle observed that soluble protein showed a decrease in early stages of infection which increased on the 20th day after inoculation and remained high till the end. But insoluble proteins in leaves were always more than the control till the 30th day and decreased thereafter. Soluble and insoluble proteins in stem and roots were lower at all stages. Ghosh and Mukhopadhyaya (1979) with their study in Cucurbita moschata during pathogenesis of some anisometric cucurbit viruses found that all the isolates increased buffer soluble proteins during later stage of pathogenesis. In Dolichos yellow mosaic infected bean leaves Singh et al., (1976) found lower levels of total nitrogen, protein nitrogen and total free amino acids as compared to corresponding level in the healthy counterparts. However, this trend was reserved in the older leaves. In papaya leaves infected with leaf reduction disease the level of total nitrogen was higher by 6% and 9%, free amino acid higher by 132% and 16%, soluble protein was lower by 24% and 6% respectively at early and late phases of disease. In insoluble protein was lower by 10% at early phase but higher by 13% at the late. Arginine accumulated at the early phase
only. Other amino acids studied accumulated at both phases with concentration being more in the early phase (Kar et al., 1983). The amino acids contents progressively decrease with symptoms advancement in eggplant suffer from little leaf disease (Panda and Kar, 1991). Steinberg et al., 1950 opined that symptomatology might be closely related to type and nature of amino acid accumulation under virose syndrome.

Phenols are compounds which contain one or more aromatic rings with one more phenolic hydroxyl groups. Phenolic compounds have been shown to play key role in the resistance of plants to disease causing pathogen (Farakas and Kiraly, 1962; Cruickshank, 1963; Tomimyama, 1963). Polyphenols are known to be powerful inhibitors of IAA oxidase (Hare, 1964), may in turn be able to reverse the enzyme activity and confer resistance via auxin spraying action on plants that produce them in response to infection (Lee and Tourneau, 1958).

In the initial phase of disease development the pathway which is normally operative in healthy plant the NADH₂ cytochrome system is enhanced. In the later stages those which are accompanied by tissue disintegration, other oxidative enzyme seems to be activated (Millerd and Scott, 1962; Goodman et al., 1967; Martin, 1958; Shankarlingam et al., 1980); ascorbic acid.
oxidase (Farakas and Kiraly, 1958, Fric and Majernik, 1964) and peroxidase (Loebenstein and Linsey, 1963; Menke and Walker, 1963; Tripathy et al., 1975; Shankarlingam et al., 1980).

Catalase activity is reported to increase in leaves (Peterfi et al., 1971a, b) or decrease (Tosic, 1971; Syenonora et al., 1972) under pathogenesis. On the contrary, the activity of peroxidase mostly increases under pathogenesis (Hirai, 1970; Peterfi et al., 1971a, b; Kato and Misima, 1972; Parish, 1972; Syenora et al., 1972; Tripathy et al., 1975).

Variation in the level of endogenous auxin have been reported for many diseases (Braun, 1962; Pegg, 1976; Sequeira, 1973; Van Andel and Fuchs, 1972; Veldstra, 1968). These variations, however, do not confirm to any definite pattern and may be species specific. In general, there is little evidence that auxin produced due to pathogenesis play an important role in initiating pathogenesis or in determining the nature of host-pathogen interaction. (Sequerira, 1973). Galston et al., 1968 stated that reduction of auxin under pathogenesis in the hosts is due to oxidation by peroxidases. The ABA-like substances accumulate in Tobacco plants infected with pseudomonas (Steadman and Sequeira, 1970). Exogenous application of GA to little-leaf diseased Catharanthus roseus brought about symptoms reversal.
as effectively as tetracycline hydrochloride (Kar et al., 1983).

Pathogenesis bring about changes in the level of micro-nutrients. Sarkar and Joshi, 1977 analysed the composition of various essential nutrient elements in eggplant under little leaf syndrome. They observed decrease in total phosphorus content in all parts except root at all stages of infection. K, Ca, Fe, and S contents also reduced due to infection. Reduction in the level of Ca, in Sessamum suffering from Sessamum phyllody (Raghupathy and Jairaj, 1977) and general depletion of essential elements in Santalum album infected with spike disease (Verma et al., 1969) has been reported.