TIPS TO NUTRIENT MANAGEMENT IN HI-TECH HORTICULTURE

Funded by Dept. of Agriculture

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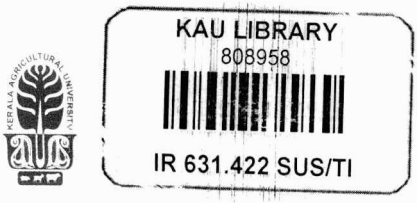

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Foreword

In Kerala, the scope of horticulture to develop as a commercial enterprise is immense. Despite the availability of favourable environmental conditions and natural resources, improper usage and mismanagement of the same along with environmental degradation have hampered crop production. Judicious application of modern agro-technologies will enhance crop productivity and will also improve farm product quality. Protected cultivation using artificial environments create better opportunities for the diversification of horticulture in the state.

Best management practices which addresses water and fertilizer usage at farmer's level is a critical decider to address the problems of water scarcity, water and environmental pollution. Such practices will boost food production, arrest environment degradation and aid sustainable irrigated agriculture. Better crop production also depends on efficient utilization of soil water and soil fertility. Timely application of the right dosage of fertilizers in the right form ensures crop productivity and product quality.

Today, the major problems faced by the greenhouse farmers are nutrient management and plant protection. Many a times, due to lack of knowledge at farmer's level, foliar symptoms caused by nutritional disorders are misinterpreted as pest / disease attack. This leads to considerable yield loss and even plant death. Precise and timely diagnosis of nutritional deficiency and toxicity disorders in plants and adopting corrective measures becomes crucial. In this, context, this book entitled "Tips to nutrient management in Hi-tech Horticulture" will be of immense value and will serve the interests of professionals and growers in greenhouse cultivation.

I am sure that the information contained in this publication will be of enormous value to professional and growers interested in protected cultivation. I sincerely congratulate Dr. P. Suseela, Associate Professor, Hi-Tech Research & Training Unit, IF Vellanikara and Dr. P.K. Sushama, Prof. and Head, Department of soil chemistry COH, Vellanikkara for preparing this book.

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Nutrients essential for plant growth

Carbon

- Non fertilizer element which is supplied to plants by nature/man through air and water in the form of CO_2 or HCO_3. Constituent of all organic compounds such as sugar, protein and organic acids.

Hydrogen

- Constituent of all organic compounds.
- Non fertilizer element which can make available to plants through air and water in the from of H_2O.
- Involved in electrochemical reaction to maintain charge across cell membranes.

Oxygen

- Constituent of all organic compounds.
- Non fertilizer element supplied to the plants through air and water in the form of H_2O and O_2. Important for many bio chemical reaction s in the plant.

Nitrogen

- Macronutrient required by the plants in large amounts. Plants take nitrogen in the form of NO_3^- and NH_4^+.
- Imparts dark green colour to plant, promotes vegetative growth of plants and increases protein content in food and fodders and plumpness of grains in cereal crops.
- Involved in structure, enzymatic reactions, genetic material etc.
- Important constituent of chlorophyll and present in many other compounds such as nucleotides, phospholipids, alkaloids, enzymes, hormones, vitamins etc.
- Regulates the utilization of potassium and phosphorus &

other constituents and translocated from oldest to younger tissues

Phosphorous

- Macronutrient required by plants in large amounts which is receiving in the form of $H_2PO_4^-$ and HPO_4^{2-}.
- Require at all stages of plant growth, but demand is more during root formation at early growth of plant.
- Involved in several key functions such as photosynthesis, cell division, carbo-hydrate metabolism, fat metabolism, nutrient movement within the plant.
- Involved in the transfer of genetic characteristics.
- Increases transformation of sugar and starches and enhances the energy transfer process.
- Intense effect on both vegetative growth and fruit set throughout the crop.
- Stimulates the flowering, fruit setting, seed formation and development of roots (particularly of root crops).
- Induces nodule formation of leguminous crop and rhizobial activity.
- An essential constituent of majority of enzymes, amino acids and ATP (adenosine triphosphate) It is also constituent of nucleic acids, phytin and phospholipids.
- Counteracts the effect of excess nitrogen.
- Develops resistance to certain diseases. If P is becoming limiting, it is translocated from older to younger tissues. Hence a regular supply of P is needed to ensure that plant can sustain the quality fruit production over a prolonged period.

Potassium

- Macronutrient required by the plants in large amounts.
- Absorbed from the soil in the form of K^+ ions.
- Influences plant water regulation by affecting cell turgor by

opening and closing of stomata .

- Located in the stomata's guard cell and neutralizes charge differences. Acts as an activator in many enzymatic reactions.
- Essential in transformation of sugars and starch.
- Influence in the formation of carbohydrates, transport of water in the plant, colour of fruits etc.
- Imparts disease resistance to plants and improves the quality of final product. Influence on fruit quality and is effective in increasing growth at high rates.
- Important for the control of growth and later for the prevention of ripening disorders. Mobile in the plant and translocated from older to younger leaves.

Calcium

- Secondary nutrient and is required by the plants in moderate amounts. Plants take calcium in the form of Ca^{2+}
- Important for functioning of cell membranes and the strength of cell walls. A co-factor for certain enzymatic reactions.
- Improves the intake of nitrogen, iron, boron, zinc, copper, and manganese by correcting soil pH.
- Soil having sufficient calcium will have good soil structure and good cation exchange capacity.
- Neutralizes organic acid which is poisonous to plants.
- Helps in translocation of sugar in the plants.
- Involves in the root elongation, cell division and there by plant growth.
- Enhances the nodule formation in leguminous plant and thereby rhizobial activity is increased.
- Increases crop resistance to certain disease.
- Acts as a buffer in plant's system and ameliorates the toxic effects of other nutrients.

Magnesium

- Secondary nutrient required by plants in moderate amounts.
- Plant absorbs in the form of Mg^{2+}.
- A constituent of chlorophyll. Helps in production of proteins, fats, vitamins, carbohydrates. Helps in certain catalytic reactions in the enzyme system.
- Indispensable for photosynthesis by plants and helps in the translocation of carbohydrates and fats.
- Increases crop resistance to drought and diseases.
- Plays important role in the synthesis of oils and fats .
- Regulates the uptake of nitrogen and phosphorus from the soil.

Sulphur

- Secondary nutrient required by plants in moderate amounts
- Plant absorbs in the form of SO_4^{2-}
- Involved in the formation of chlorophyll and encourages vegetative growth. Not a constituent of chlorophyll.
- Accelerates root growth and stimulates seed formation.
- Helps in oxidation - reduction reactions, respiration and activation of fermentation.
- Essential for the synthesis of certain amino acids such as cystine, cysteine and methionine. Master nutrient for oil seed formation.
- Promotes the nodule formation on the roots of leguminous plant.
- Presence of sulphur compounds develops a pungent odour in onion and garlic.

Iron

- It is a micronutrient required by plants in small amounts.
- Absorbed by plants in form of Fe^{2+} and chelates.
- Plays an important role in the formation and activity of a

series of respiratory enzymes and has a catalytic role in the activities of several enzymes.

- Part of one of the enzyme that is responsible for the reduction of nitrate nitrogen. Essential for the synthesis of proteins contained in the chloroplast.
- Regulates respiration, photosynthesis and reduction of nitrates and sulphates
- Takes part in the synthesis of chlorophyll and imparts dark green colour to plants.

Manganese

- Absorbed by the plants in the form of Mn^{2+} or chelate .
- Required in small amounts (micro nutrient).
- Helps in the synthesis of chlorophyll.
- Supports for movement of iron in plant.
- Acts as a catalyst in oxidation and reduction reaction within the plant cell.
- Involves in the electron transport system in photosynthesis.
- Helps in protein synthesis in chloroplast
- Needed for respiration and nitrate assimilation

Zinc

- Required by plants in small amounts
- Absorbed in the form of Zn^{2+}/$Zn(OH)_2$/Chelate
- Takes part in the synthesis of chlorophyll.
- Involves in the biosynthesis of plant growth hormone (IAA) and in the reproduction of certain plants.
- Acts as an activator of enzymatic reactions like carbonic anhydrate and alcohol dehydrogenses. Have positive role in photosynthesis & nitrogen metabolism.
- Required for seed production, growth of plants and RNA synthesis.

Copper

- Required by plants in small amounts.
- Absorbs in the form of Cu^{2+} and Chelate
- Helps in the synthesis of chlorophyll.
- Essential for the synthesis of vitamin A and other compounds in plants.
- Acts as an electron carrier in many oxidation-reduction reactions in plants.
- Acts as catalyst in respiration and involved in the utilization of iron.

Boron

- Required by the plants in small amounts and is absorbed in the form of $H_2BO_3^{-1}$ and HBO_4^{-2}
- Important role in the development and differentiation of tissues, carbohydrate metabolism and translocation of sugar in plants
- Helps in the absorption of N. Acts as regulator of K/Ca ratio in the plants.
- Helps in root development and flower & pollen grain formation

Molybdenum

- Micronutrient required by the plants in small amounts, which absorbs in the form of MoO_4^{2-} and $HMoO_4^{1-}$
- Enhances the symbiotic nitrogen fixation, protein synthesis and regulates several enzymes.
- A constituent of two enzymes involved in nitrogen metabolism.

Chlorine

- Micronutrient required by plants in small amounts. Plants

absorbs in the form of Cl^-

- Essential in the transfer of electron from water to photo oxidised chlorophyll during photosynthesis.

Need for Foliar Nutrient spray

Leaf symptoms can give a quick clue of plant nutritional disorder. Pocket type LED meters can be used to test nitrate-nitogen and potassium supply in plants like cucumber. Pocket sized meters are also available for testing; pH, ozone, EC, chlorine, iron, copper, nitrate, nitrite, ammonium phosphate, magnesium, potasium, calcium, molybdenum manganese, sodium and aluminium. The nutritional disorders may lead to considerable yield loss and even plant death. Hence remedial actions has to be taken quickly.

Nutrient deficiency symptoms usually appear on the plant when one or more nutrients are in short supply. In many cases, deficiency may occur when the applied nutrient is not in the form the plant can use. Every soil is not susceptible to the same nutrient deficiencies. For example, Coarse-textured soils are low in organic matter content and are susceptible to sulfur deficiencies. Whereas, sulfur is usually in adequate supply in clayey soils or in soils having high organic matter. Nutrient deficiency symptoms can be corrected either by adding commercially available chemical fertilizers in the soil or through fertigation using water soluble fertilizers or by foliar spray.

Foliar sprays helps to avoid the micronutrient problems in the plants quickly: It takes only a very small amount to correct the deficiency. Many micronutrients are readily fixed by most soils and unavailable with soil fertilization. The advantages of foliar spray compared to soil fertilization are immediate response and convenience of combination sprays. In protected cultivation (in greenhouses) where rate of transpiration is low, foliar sprays are more effective. As the plant ages and at

reproductive stage (annuals), root growth and activity decreases. Nutrient uptake is energy dependent process. Strong reproductive sink compete with root for photo assimilates, and hence root activity decreases. When fertilizer is applied via soil the nutrients must first be taken up by roots and then transported through the stem and petioles to the leaves. Hence it is having late response and low efficiency. Moreover, these processes consumes energy. Nutrient content of the leaf is positively correlated with yield. Any excess of one nutrient cannot compromise for a deficiency of another nutrient, on the contrary limits the yield. When the nutrient level is above the critical level then only optimum yields can be achieved. Foliar sprays helps to make nutrients available to the plants quickly for its needs. At the same time, it should be keep in mind that foliar fertilizers are not a substitute for soil fertilization but an effective additional means of supplying sudden demands.

Optimum time of day:

Morning sprays are best (when temperature is below 27 ^{0}c - between 7.30 am to 9.30 am in poly houses and in open field, foliar spray can be made either in early morning or evening - between 7 am to 9 am and 4.30 pm to 6 pm). High relative humidity during the time of application increases absorption of foliar nutrients as it causes swelling of cuticle that loosens its components and thus enhanced absorption of hydrophilic compounds. The spray deposit evaporates slowly and so there is less danger to the leaves being burned by bright sunlight. The high humidity in the evenings and during the night causes the nutrients from dried spray deposits to be dissolved so that they can enter the leaf.

Foliar Application Rates

Generally micronutrients (B, Fe, Mn, Cu, Zn, Mo etc.) are

applied as 1 % solutions in Low volume sprays in case of field crops and as 0.1 % sprays in high volume sprays in horticultural crops.

Macronutrients (N, P and K) are applied at higher concentrations

1-2 % in field crops

0.1-0.5 % in vegetables

0.5 % in tree crops

Spray volumes for wetting the leaves to the point of runoff

500-800 lit /ha in Vegetables

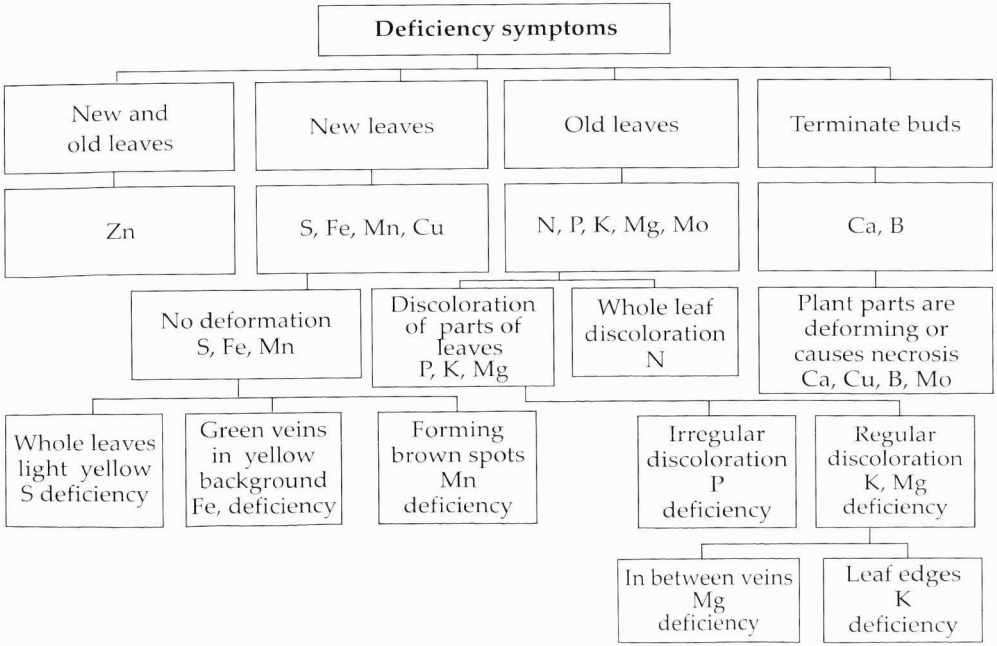
1500 lit / ha in tree crops

300-500 lit /ha in field crops

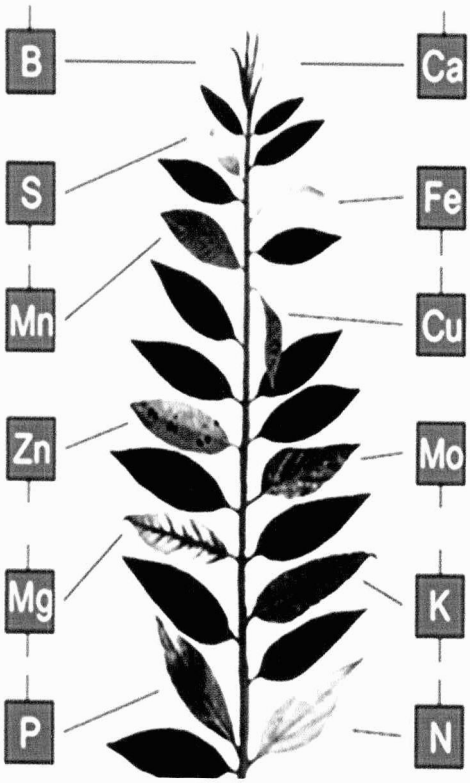
Stages at which Foliar application to be provided

Vegetable crops like Brinjal, Tomatoes, Capsicum, chilli, okra, cabbage, cauliflower, gourds, beans etc.:	20 days after sowing or transplanting, one week before flowering and one week after flowering/fruit setting
Leafy vegetables	At the interval of 20-25 days after sowing till harvesting.
Floriculture	Once in a week till last harvesting.
Flowering and vegetable crops in green houses	Once in a week till last harvest.
Nursery plants, ornamental plants and kitchen garden crops.	Once in a week till last harvest.

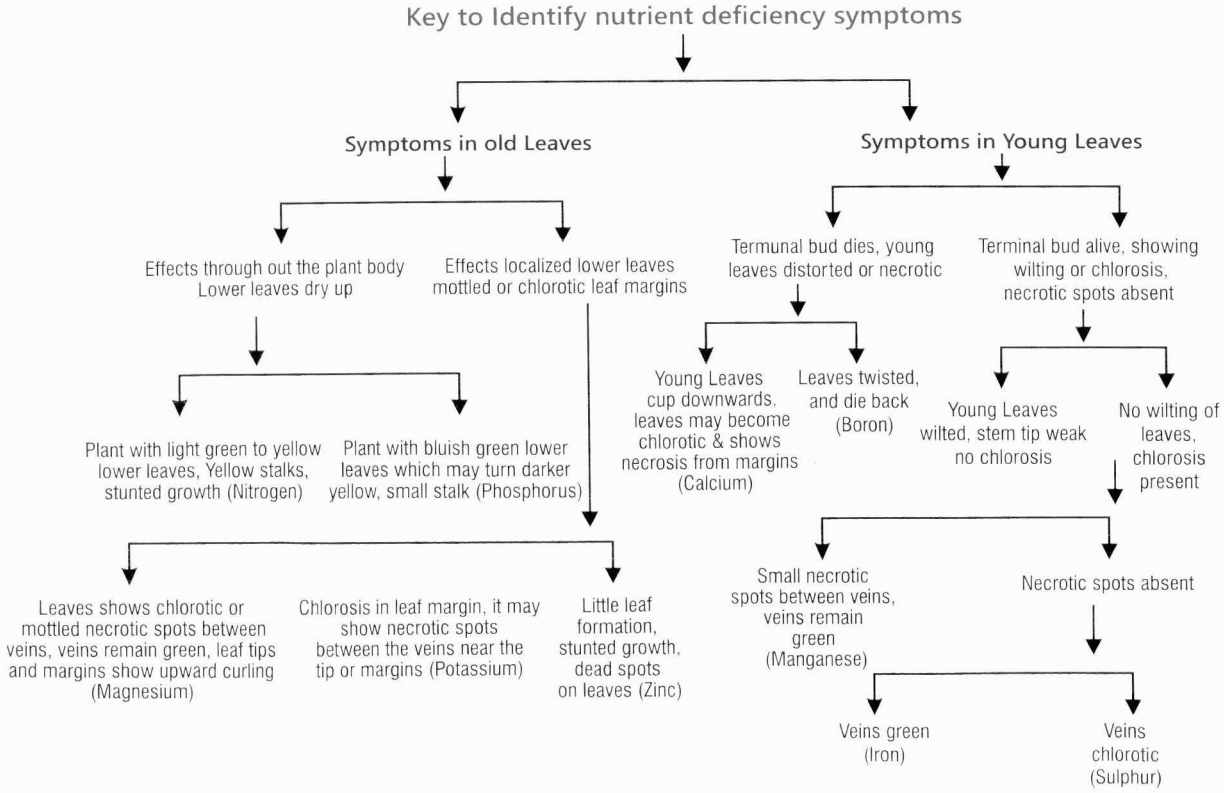
Identification of Deficiency symptoms



Nutrient deficiency & toxicity symptoms and remedies



Deficiency symptom on	Nutrient element
Terminal buds	Ca, B
New leaves	Fe, Mn, S, Cu
Old leaves	N,P,K Mg, Mo
Old and new leaves	Zn


Key to Identify nutrient deficiency symptoms
Symptoms in old Leaves
Symptoms in Young Leaves
Effects through out the plant body Lower leaves dry up
Effects localized lower leaves mottled or chlorotic leaf margins
Termunal bud dies, young leaves distorted or necrotic
Terminal bud alive, showing wilting or chlorosis, necrotic spots absent
Plant with light green to yellow lower leaves, Yellow stalks, stunted growth (Nitrogen)
Plant with bluish green lower leaves which may turn darker yellow, small stalk (Phosphorus)
Young Leaves cup downwards. leaves may become chlorotic & shows necrosis from margins (Calcium)
Leaves twisted, and die back (Boron)
Young Leaves wilted, stem tip weak no chlorosis
No wilting of leaves, chlorosis present
Leaves shows chlorotic or mottled necrotic spots between veins, veins remain green, leaf tips and margins show upward curling (Magnesium)
Chlorosis in leaf margin, it may show necrotic spots between the veins near the tip or margins (Potassium)
Little leaf formation, stunted growth, dead spots on leaves (Zinc)
Small necrotic spots between veins, veins remain green (Manganese)
Necrotic spots absent
Veins green (Iron)
Veins chlorotic (Sulphur)

Nutritional Deficiencies

Nitrogen (N)

Nitrogen deficiency usually occurs in coarse-textured soils with low organic matter content that subjected to excessive leaching. Most plant needs N in large amounts. It is required in the production of chlorophyll (green pigment in leaves) which is responsible for converting sunlight to usable plant energy.

Deficiency symptoms

- Initially older leaves of plant become light green in colour
- New leaves become small but remain green. Under prolonged deficiency, leaves may fall prematurely.
- If problem is not corrected, yellowing spreads to younger leaves. Yellowing of leaves is uniform over the entire leaf including the veins.
- Chlorosis progresses from light green to yellow and die .
- Scorching of leaves may occur starting from tip .
- Root growth gets severely affected.
- Poor growth rate and plant remains stunted
- Reduction in inter-nodal length.
- Necrosis of leaves during severe deficiency.
- Tillering / branching affected. Older leaves may wilt under mild water stress and senesce much earlier than usual.
- The flower bud often turns pale and shed prematurely.
- Causes early maturity. Entire plant becomes yellow under prolonged stress.
- The leaves and young fruits tend to drop prematurely.
- No of fruits formed get reduced and few fruits formed became yellow-green in colour.
- Fruits do not attain their normal size and becomes wrinkled and light in weight
- N deficiency in cowpea exhibit gradual yellowing of old as

N deficiency

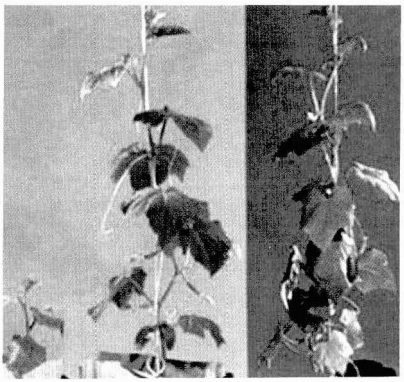


Fig.2. Scorching of leaves may occur starting from tip (Cauliflower)

Fig.1a,1b. Old leaves become light green and then changed to yellow (Salad cucumber)

Fig.3. Poor growth rate (Capsicum)

Fig.4. Short inter-nodal length (Egg plant)

Fig.5.Entire plant becomes yellow (Capsicum)

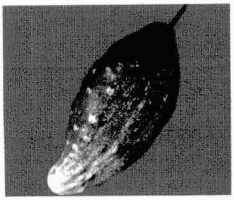


Fig.6.Fruits do not attain their normal size and becomes wrinkled (salad cucumber)

Fig.7.Cowpea exhibit gradual yellowing of old as well as young leaves but the veins remain green

well as young leaves. The veins remain green and the acute deficiency causes stunted growth and leaf drying

Remedy

- Soil application of nitrogenous fertilizers like ammonium sulphate/urea/ammonium chloride/calcium ammonium nitrate etc.
- In case of soil grown crops, side dressing of 20-50 kg/ha of nitrogen is sufficient.
- Foliar sprays of 0.1 to 0.2% of urea fortnightly will give good results. Recovery of N deficient plant is immediate & spectacular.
- In the case of hydroponic cucumbers, use nutrient solution containing 150-200 ppm
- Foliar application of nitrogen has to be made at high humid condition.
- In order to prevent salt burn to leaves, foliar application in polyhouse has to be done early morning or after operating fogger for few seconds. In open precision farming, it is better to give foliar spray either in early morning (between 7am to 9am) or in late evening
- Under hot and bright conditions, the nitrogen level must be increased to enable the plant to continue growing and to ensure the maximum production potential of the fruit.

Phosphorus (P)

P deficiency usually seen in acidic soils having low organic matter content/ cold wet soils that occurs in cold regions during early spring / in newly cleared soils.

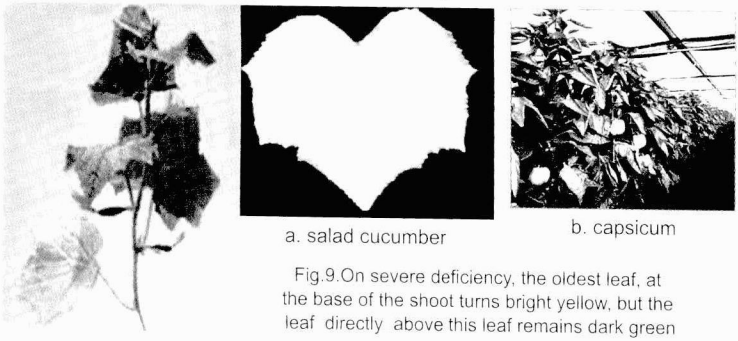
Deficiency symptoms

- Symptoms first appear on basal leaves.
- Plants show stunted growth even under abundant supply of nitrogen and potassium.
- Root and shoot growth is restricted and plants become thin and spindly.
- Leaves appear dull, bluish green / purple colour, especially on the underside and at the midrib and vein .
- Petioles may also exhibit purpling and restriction in growth may be noticed.
- Phosphorus-deficient plants have elongated roots with few laterals (weak roots) and are stunted.
- On severe deficiency, the oldest leaf, at the base of the shoot, turns bright yellow. However, unlike nitrogen deficiency, the leaf directly above this leaf remains dark green.
- On prolonged deficiency, older leaves show brown, scorched spots between the veins. Leaves develop necrosis.
- There will be reduction in the distance between leaves and becomes close to the stem.
- Leaves may shed prematurely and flowering and fruiting may be delayed considerably and fruit set may get reduced and cause considerable reduction in production.
- Premature ripening of crop may occur.
- Stems develop reddish coloration.

Remedy

- As younger seedlings of most of the vegetable crops demands P for early root growth, half of plant requirement has to be

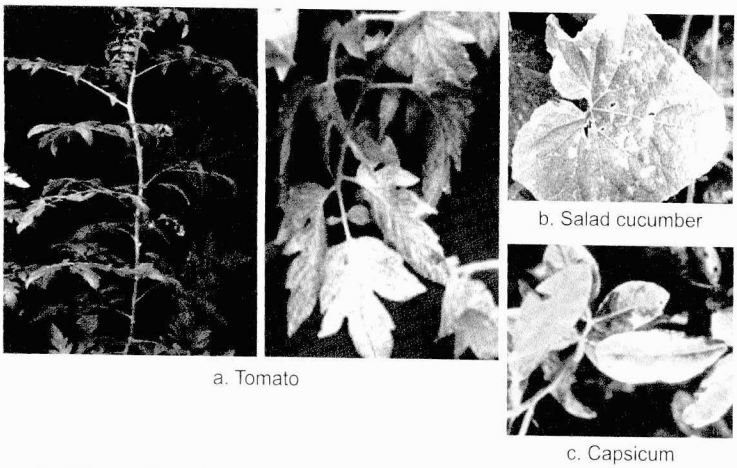
P deficiency



a. salad cucumber

b. capsicum

Fig.9.On severe deficiency, the oldest leaf, at the base of the shoot turns bright yellow, but the leaf directly above this leaf remains dark green



a. Tomato

b. Salad cucumber

c. Capsicum

Fig.10a, b, c. On prolonged deficiency, older leaves show brown scorched spots between the veins and develop necrosis

Fig.10d.Purple discolouration near the margins in capsicum

supplied as basal doze and remaining half portion has to be supplied through fertigation as water soluble phosphates.

- Absorption of P occurs during the whole crop cycle but is more intense between 15 and 60 days after emergence. Hence, phosphatic fertilizers like super phosphate/rock phosphate has to be applied in the soil as basal doze
- Soluble phosphatic fertilizers like mono potassium phosphate (MKP)/mono ammonium phosphate can be applied through drip system or foliar spray.
- Phosphate based fertilizers should not be mixed with calcium based fertilizers. Magnesium is compatible with phosphates only at low concentrations and low pH
- Use of mycorrhizae or VAM (2 to 4g.) at the time of laying seeds in seedling tray will helps the plants to absorb 'P' from more area.
- Supply P as foliar sprays 3 to 4 times during the crop growth to overcome the problem of non-availability of P during later crop growth periods when the active roots are deep in the soil profile where the availability of nutrient from the fertilizer applied is likely to be very limited.
- For hydroponic cucumber production, nutrient solution, containing 25-50 ppm 'P' has to be used
- In tuber crops, during last crop stages, the plant transfers phosphorus from the aerial part to the tuber. Hence, foliar applications of phosphorus late in the season can favour production
- The plant can absorb phosphorus only from a distance not exceeding 2 mm from the root hairs.

Potassium (K)

- Deficiency occurs due to excessive leaching caused in coarse-textured, low organic matter soils

Deficiency symptoms

- Deficiency first appear on older leaves.
- Deficient plants show a reduced rate of photosynthesis & hence growth get restricted.
- Typically, chlorosis first appears at the leaf margins. The marginal yellowing spreads between veins towards centre. As deficiency progresses, small, pale brown areas may develop; these are usually, though not exclusively, interveinal. Plant shows chlorosis followed by necrosis at the tip and margins. Large areas of tissue around the major veins remain green until the deficiency is well advanced.
- Small reddish brown spots develop on mature leaves. These spots usually spread from leaf tips.
- On severe deficiency, plant shows yellow and scorched older leaves, which further turn dry and papery. Symptoms progress from the base towards the apex.
- Curling of leaves may also occur.
- On outdoor plants yellowing occurs near the margins of the leaves, but marginal browning is the predominant feature.
- The margins of the young, fully expanded leaves become yellow and scorch (pale brown) rapidly and cup downward in hot weather.
- Shortened internodes with stunted growth and plant become bushy.
- Potassium deficiency resulting leaf bleaching in cucumber.
- Leaf symptoms are accompanied by abnormal fruit development, often with brown or spotted appearance. In some of the plants, when grown with insufficient K, ripening of parts of the fruit wall is delayed, resulting in green (later

yellow) areas on riped red fruit. The size of the abnormal areas depends on the severity of the deficiency.

- Problems with fruit quality, such as blotchy ripening, boxy fruit, and even to some extent, greenback are associated with low levels of potassium and in most cases can be neutralized with high-potassium feeds
- Fruits fail to expand at the stem end which is clearly visible in the case of salad cucumber. This symptom can also caused due to water stress
- It is also responsible for the die back of shoots .

K deficiency

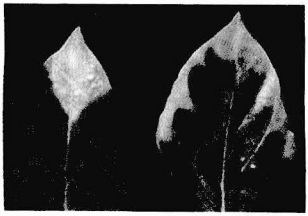
a. Salad cucumber

Fig.11a,b,c.Chlorosis first appears at the leaf margins

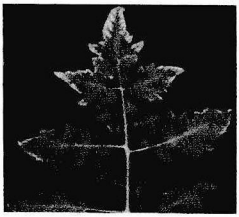
Remedy

- Incorporate Muriate of potash/ potassium sulphate/Multi-K(potassium nitrate) in the soil before planting.
- Potassium can be supplied from potassium chloride (avoid in low PH soils), potassium sulphate, potassium thio-sulphate, or potassium nitrate through fertigation.
- It is preferable to do fertigation using potassium nitrate or Multi-K to treat a deficient crop.
- In sandy soils, where quick response to potassium fertilizer is expected, application of soluble Multi-K, may result in fast correction of the deficiency.
- Reduced solubility may be possible when calcium nitrate and potassium sulphate are mixed as it will yield insoluble

K deficiency

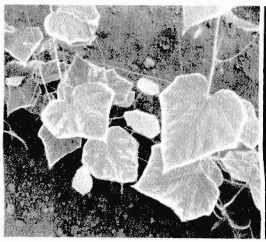


b. Capsicum

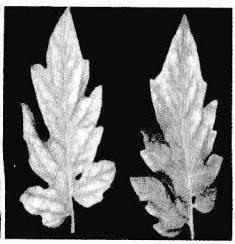


c. Tomato

Fig.11a,b,c.Chlorosis first appears at the leaf margins



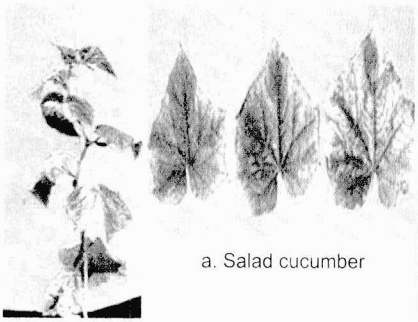
a. Salad cucumber



b. Tomato

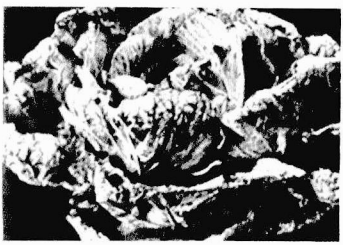
c. Chinese cabbage

Fig.12a,b,c.The marginal yellowing spreads interveinally as the deficiency progresses, and small, pale brown areas develop



a. Salad cucumber

b. Egg plant



c. Cabbage

Fig.13a,b,c.Yellow scorched older leaves further turn dry and papery and curling of leaves may also occur

K deficiency

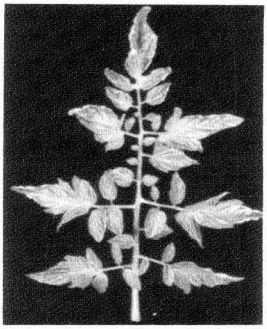


Fig.14.Some yellowing occurs near the margins of the leaves on out-door plants

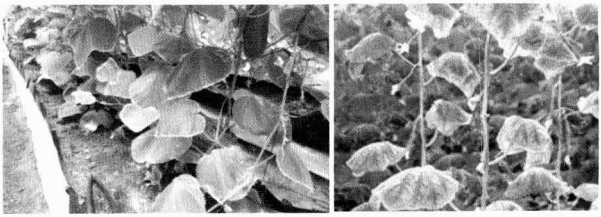


Fig.15. Potassium deficiency resulting leaf bleaching in cucumber

Fig.16a. Ripening of parts of the fruit wall get delayed, resulting in green areas which later becomes yellow.

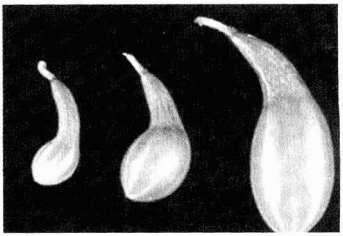


Fig.16b. Fruit fails to expand at the stem end.

Fig.17. Dying back tips of shoots

calcium sulphate. Similarly, if there is salinity problem, potassium chloride and potassium sulphate should be avoided for fertigation.

- Foliar sprays with soluble Multi-K /sulphate of potash or Poly-Feed (2 to 5ml/lit) is effective and can cure the K deficiency within a short period of time.
- Foliar sprays of organic fertilizers like Nano potash/Nano NPK (3 ml/lit) at 14 days interval will also provide very good result
- For crops grown in soilless media, use a nutrient solution containing 150–200 ppm K.
- The ratio between potassium and nitrogen is also important in growth control; higher the ratio, the slower will be the growth. Proper management of irrigation and a stable salt content of the soil solution will avoid blotchy ripening. Better K nutrition will tend to increase water content of the plant tissue.
- Foliar spray of potash will also help to produce systemically induced disease resistance
- Fruit gray mold caused by *Botrytis Cinerea* can be reduced by 27%-33% by the application of supplemental K to parthenocarpic cucumbers.
- Foliar sprays of potassium salt solutions have been shown to control Powdery Mildew caused by *Sphaerotheca fuliginea.*
- Do not over apply potassium fertilizer, especially in light soils or in soilless systems, as excessive K causes N deficiency in the plants and may affect the uptake of other cations such as Mg and Ca
- The plant can absorb potassium from a distance of about 7 mm from the root hairs.

Calcium (Ca)

Ca deficiency caused due to excessive leaching in coarse-textured low organic matter content soils and also in soils where large amounts of K have been applied. Calcium deficiency can also be caused due to the acidity in the soil / high humidity in atmosphere / water logging / soil salinity / supply of ammonium fertilizers to plants / root disease etc. Rapidly growing crops in hot and dry conditions are showing more deficiency symptoms. If crops grow quickly under continuously humid conditions (eg. salad cucumber), chances for deficiency is high. Plant takes Ca slowly as roots has to exchange two hydrogen ions for one Ca ion (only one hydrogen ion has to be exchanged for a K ion). Ca moves in plants transportation stream and is deposited mainly in older leaves.

Deficiency symptoms

Deficiency will be first observed in growing tips and young leaves which have low rates of transpiration and on severe deficiency, symptoms get extended towards older leaves.

- Mature and older leaves are generally unaffected.
- Youngest leaves of calcium deficient plants cup downwards and their edges become scorched because leaf margins fails to expand fully.
- Leaves become deformed, chloric and at most advanced stages shows necrosis from margins.
- On prolonged deficiency, growing points get damaged or dead .
- The normal growth of plant gets arrested and results stunted root growth. Roots may become short, stubby and brown.
- May resemble boron deficiency.
- There will be reduction in growth of meristematic tissue
- Usually expressed as blossom end rot of the fruit and as dieback of the growing tips.

- Blossom end rot begins as small, brown patches at the blossom end of green fruit which later turn into light brown tissue necrosis on the blossom end and finally it collapses & secondary pathogens take over the fruit.
- Less severe Ca stress may result in the formation of sunken greyish-brown spots near the stylar scar and blackening of part of the placenta
- Blossom end rot gradually develops into black sunken lesion on the blossom end. Later, blossom end rot gradually develops into a large, sunken, leathery lesion. These lesions are not associated with soil contact. Fruit with blossom end rot ripen prematurely and are inedible.
- On severe deficiency, internal and external blossom end necrosis will occur .
- Blossom end rot develops on fruit receiving insufficient Ca. Affected fruit generally contain less than 0.08% Ca whereas healthy fruit frequently contain 0.12 - 0.25% Ca.
- With severe deficiency, flowers can abort. Fruits from calcium deficient plants are smaller & tasteless and may fail to develop normally at the blossom end, which is clearly visible in the case of salad cucumber.
- On severe deficiency, the acidity of cell saps increases abnormally and it hampers the physiological function of the plant. As a result of which plant suffers illness and causes the death at last.

Remedy

- Add calcium carbonate or calcium hydroxide or dolomite in the soil based on pH. If crops are grown in soilless media, use a nutrient solution containing fully soluble calcium nitrate.
- Always keep the conductivity of water in the growing medium below 2 dS/m as the incidence of deficiency increases with increasing conductivity.

Ca deficiency

Fig.18. Curled Cucumber leaves

Fig.19. Necrosis of leaf margins, crinkling of the youngest leaves and petiole collapse

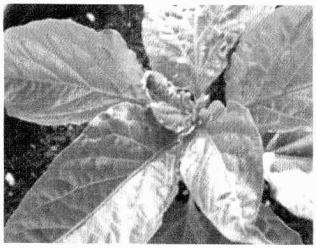
a. Salad cucumber

b. Cabbage

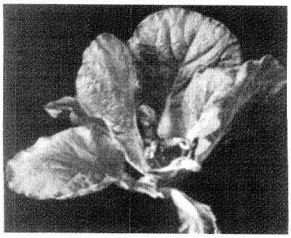
c. lettuce

Ca deficiency

d. cauliflower



e. Capsicum



f. Chinese cabbage

g. Capsicum

Fig.20 a,b,c,d,e,f. g. On prolonged deficiency, growing points usually damaged or dead

Fig.21. Blossom end rot begins as small, brown patches at the blossom end of green fruit.

Fig.22. Light brown tissue necrosis on the blossom - end.

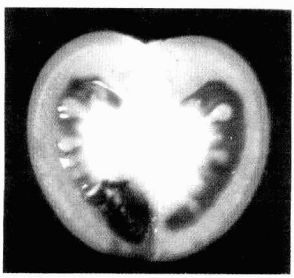
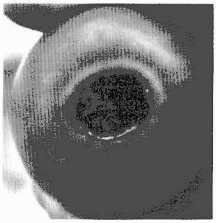
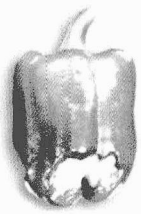


Fig.23. Less severe Ca stress may result in the formation of sunken greyish-brown spots near the stylar scar and blackening of part of the placenta.

Ca deficiency



a. Tomato



b.Capsicum

c. Water melon

Fig.24 a,b,c.Black sunken lesion on the blossom - end.

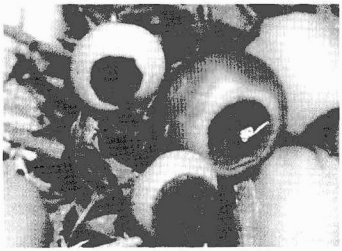


Fig.25.Blossom end rot gradually develops into a large, sunken, leathery lesion.

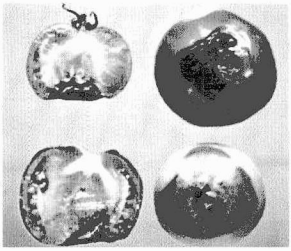
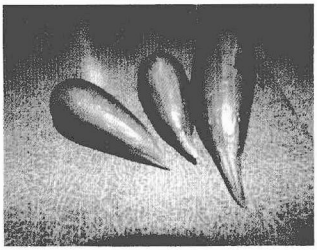
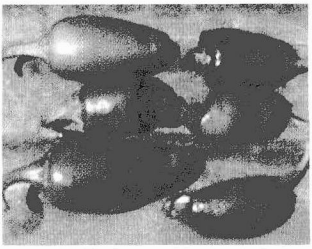


Fig.26.Internal and external blossom-end necrosis. Fruit with blossom-end rot ripen prematurely and are inedible.



salad cucumber



Chilly

Fig.27.Fruits fail to expand at the tail end

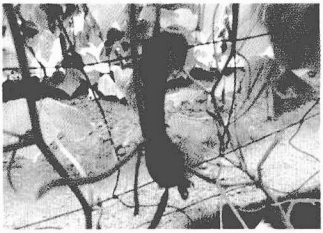


Fig.28. Cucumber plant suffering Ca and K deficiency

Fig.29 K and Ca deficiency in Tomato

- Reduce the use of ammonium based fertilizers. Applying lime to acidic soils and reducing the use of ammonium- based fertilizers will help to avoid calcium deficiency in the soil.
- Regular foliar spray (once in 2 weeks in poly houses) of fully soluble calcium nitrate (2g/lit) will reduce the existing injury from calcium deficiency.
- Foliar application of organic fertilizer "Nano CAL" (3ml/lit) will reduce the existing injury from calcium deficiency. Application of "Nano CAL" (3ml/lit) at 14 days interval (one week before flowering, one week after flowering and one more spray after 14 days) will help to avoid flower/fruit drop and hence help to increase the yield
- In most cases, calcium deficiency is not in the soil but is induced. The most likely cause is water stress on the plant resulting from inadequate or uneven watering, frequent and large variations in relative humidity, or a high level of salts. Though foliar sprays of calcium nitrate or calcium chloride will help to correct the calcium deficiency, improving water balance in the plant is a more practical solution to this problem.
- As calcium, magnesium and potassium compete with each other, increase in one of them will affect the absorption of other two by the plant.
- Uptake of Ca is only through tips of roots

Magnesium (Mg)

Mg deficiency caused due to excessive leaching in coarse-textured soils with low organic matter content and also in soils where large amounts of K have been applied. Deficiency may also occur if soil is acidic and having high EC. Deficiency symptoms are more common during cold weather in heavy soils when roots are less active.

Deficiency symptoms

- Magnesium deficiency causes yellowing of older leaves which may spread towards younger leaves on severe deficiency.
- The symptom begins between the major veins, which retain a narrow green border. A light tan papery burn will develop in the yellow regions if the deficiency is severe.
- Marginal chlorosis, chlorotic blotches will merge later.
- Leaves show Interveinal chlorosis and in extreme cases, the chlorotic areas may become necrotic, brittle, and curl upward . It may be yellow chlorotic interveinal tissue on some species, reddish purple progressing to necrosis on others.
- Symptoms usually occur late in the growing season.
- Fruit yields get reduced.
- Anthocyanin formation get affected
- Premature leaf fall
- Sometimes deficiency symptom of Mg may get confused with spider mite damage in cucumber .

Remedy

- Add magnesium rich materials like magnesite ($MgCO_3$ – 28.8% Mg or 47.81% MgO) at 300 kg/ha or Dolomite ($CaMg(CO_3)_2$21.7% Ca, or 30.4% CaO and 3.2% Mg or 21.96% MgO), at 800 kg/ha in the soil before planting .
- Fortnightly foliar sprays of fully soluble magnesium nitrate

Mg deficiency

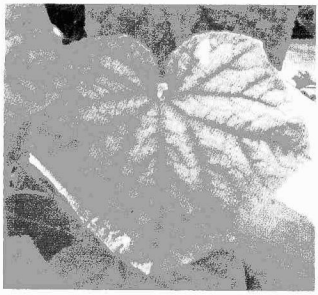


Fig. 30. veins of chlorotic leaves remain green in colour

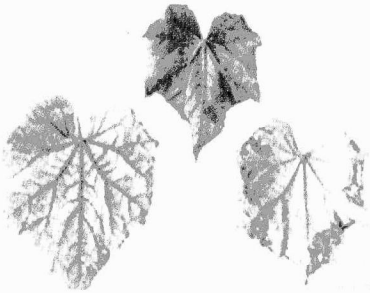


Fig.31. Yellowing between the major veins of older leaves (left) turns to a light tan papery burn (right). Younger leaves (top) are less affected.

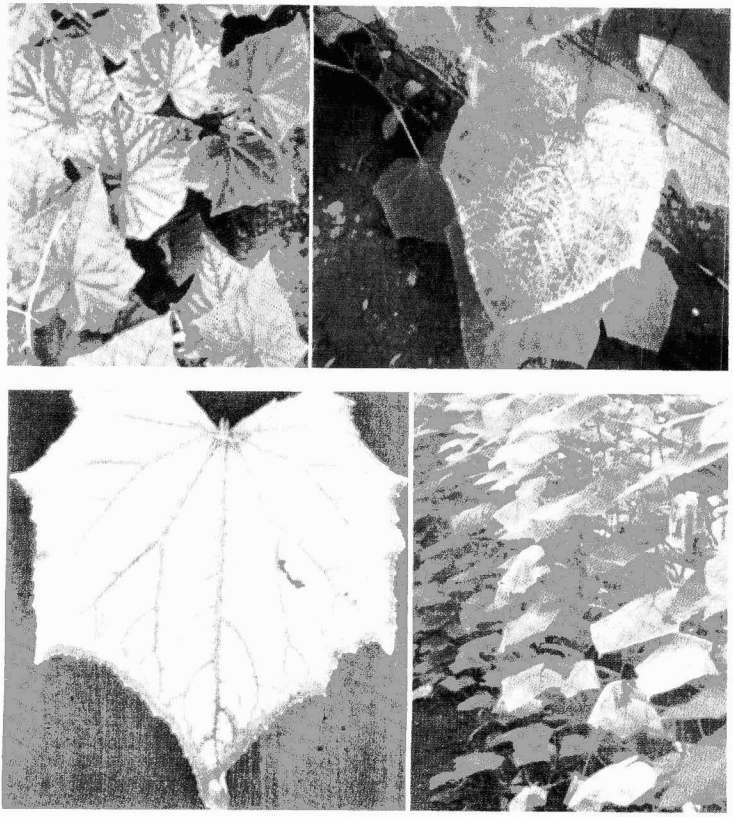


Fig.32. Progress of Mg deficiency symptoms in salad cucumber

Mg deficiency

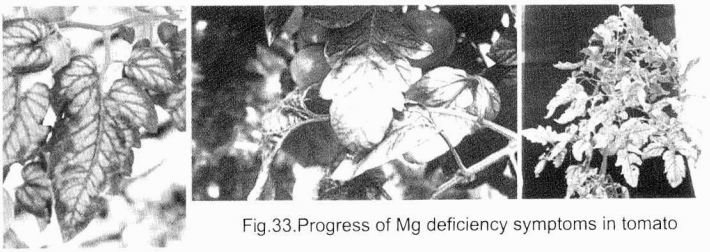


Fig.33.Progress of Mg deficiency symptoms in tomato

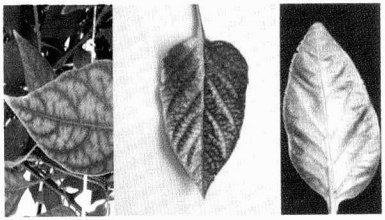


Fig.34.Progress of Mg deficiency symptoms in capsicum

Fig.35.Progress of Mg deficiency symptoms in Yard long bean

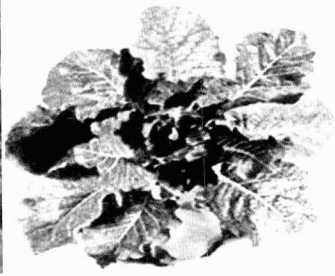
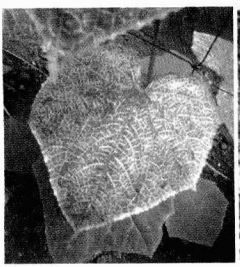


Fig.36.Magnesium deficiency in cabbage

Fig.37.Magnesium deficiency Chinese cabbage



Spider mite damage

Magnesium deficiency

Fig.37a. Resemblance of Magnesium deficiency & Spider mite damage

(11-00+16 MgO), e.g. Magnisal® at 2 kg/ 100lit) or foliar application of fully soluble $MgSO_4$ (2-3g/lit) solution will help to correct the deficiency

- Foliar application of organic fertilizer "Nano CAL" (3ml/lit) will reduce the existing injury from Magnesium deficiency.
- Magnesium deficiencies can be induced by heavy rates of potassium fertilizers. Hence avoid the use of heavy dose of K fertilizers.
- Rarely results in yield reduction. But, it may cause entry points for botrytic and other diseases.
- Deficiency may exists in the plant, even though Mg is present in the soil. This may be due to high-potassium feeds or poor root development. Both will make difficult for the plant to take in sufficient magnesium, thereby forcing the plant to move magnesium from the old leaves to the new leaves.

Manganese (Mn)

Mn deficiency occurs in coarse-textured low organic matter content soils subjected to excessive leaching or in soils with pH > 6.5 (alkaline soils). It is likely to happen when amounts of Ca, Zn, Mg or Al are more in soil .

Deficiency symptoms

- First appear on younger leaves
- May be confused with iron deficiency and is often an expression of iron toxicity
- Leads to Interveinal chlorosis of the younger leaves (chlorosis on older leaves is caused by magnesium deficiency).
- The veins of middle to upper leaves of manganese-deficient plants remain green while the rest of the leaf portion becomes a uniform pale green to yellow.
- Poorly developed root system
- Chlorotic areas eventually become brown, transparent, or necrotic.
- Later, necrotic spots scattered over the leaves
- On acute deficiency, symptoms may appear later on older leaves.

Remedy

- Provide soil application of $MnSO_4$ (1 Kg/1000 sqm) or foliar spray of $MnSO_4$ (1g/lit of water)
- For hydroponic cultivation of cucumber, use a nutrient solution having 0.3 ppm Mn

Mn deficiency

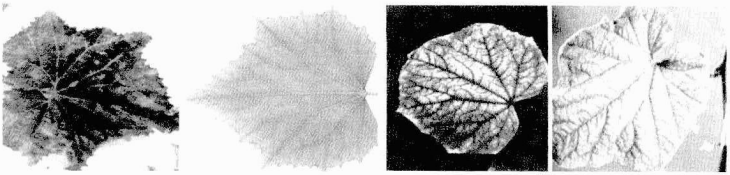


Fig.38a. Progress of Mn deficiency in salad cucumber

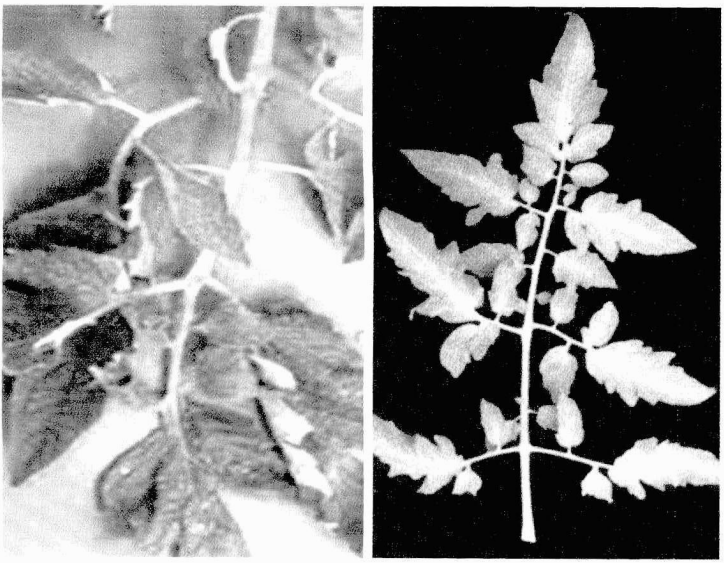


Fig.38b. Progress of Mn deficiency in tomato

Fig.38c. Mn deficiency in capsicum

Mn deficiency

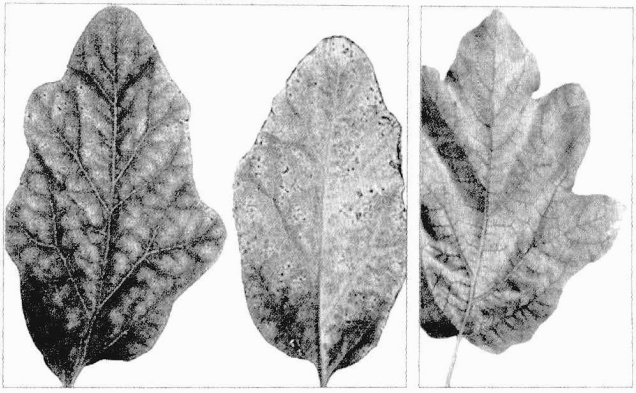


Fig.38d. Mn deficiency in Egg plant

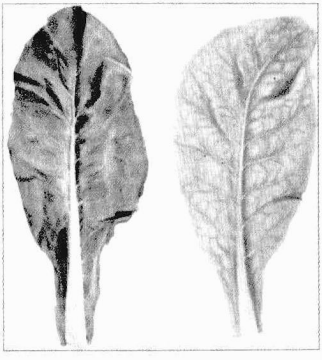


Fig.38e. Mn deficiency in Cauliflower

Fig.38f. Mn deficiency in Cabbage

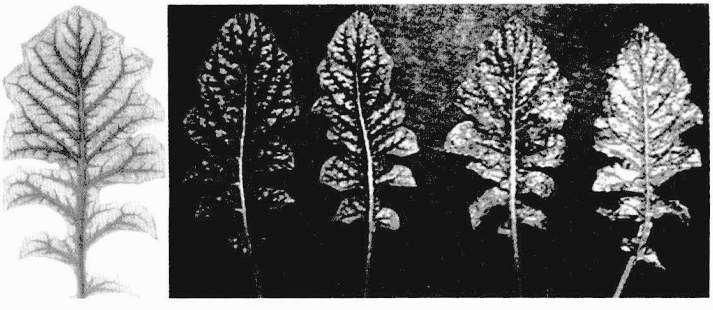


Fig.38g. Progress of Mn deficiency in gerbera

Molybdenum (Mo)

Molybdenum deficiency can occur due to high acid soil conditions or due to high sulphur levels in soil. Deficiency usually seen in coarse textured soils which is low in organic matter. Plants growing in acidic soils having moisture stress is susceptible to molybdenum deficiency. Deficiency also occurs in the soils having high iron oxides / in soil cropped with plants having high adsorption of molybdenum for a long time.

Deficiency symptoms

- Symptoms start first in lower leaves and spread upwards, the younger ones remaining green.
- Initially, growth might appear normal but flowers stay small. The green colour of the leaves fades, particularly between the veins. Later, leaves can turn yellow and die. In some cases, parts of mature leaves remain green at first, giving rise to a blotchy appearance.
- Chlorotic interveinal mottling of basal leaves.
- Leaves may fold inwards and remain small .
- Abortion of flowers
- In extreme deficiency, leaf lamina is not formed and only mid rib is present ('whiptail' in cauliflower, broccoli & other brassica crops)
- Deficiency also causes downward cupping in radish & scald in beans.
- On severe deficiency, dead spots can be seen all over the leaf area except veins.
- In affected area, extruded sticky gum through lower leaves.
- On acute deficiency, the youngest leaves become light green and malformed.
- Flower formation is inhibited & if flower do form, they abscise before setting of fruits.
- Reduces the activity of symbiotic and non symbiotic nitrogen

fixing organism.

- Deficient legumes will not nodule well or fix the normal amount of nitrogen expected of them.

Mo deficiency

Fig.39. Chlorotic interveinal mottling of basal leaves

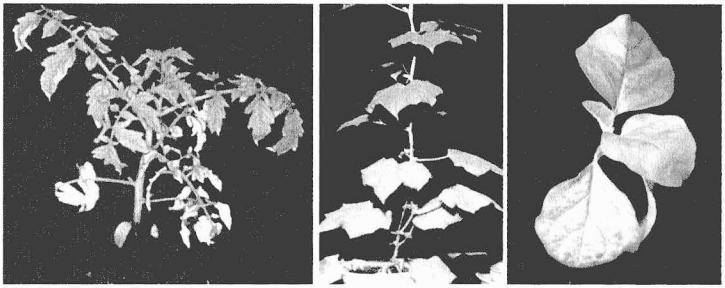


Fig.40.Leaves may fold inwards and remain small

Salad cucumber

Egg plant

Fig.41. molebdinum deficiency in salad cucumber and egg plant

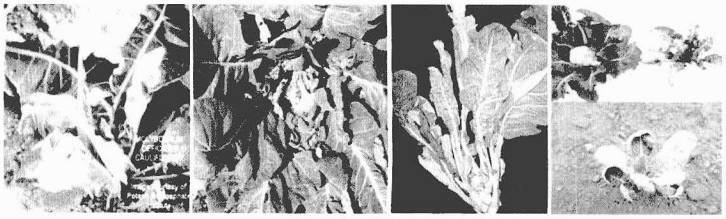


Fig.42.Molybdenum deficiency in cauliflower

Remedy

- Soil and foliar application of sodium molybdate or ammonium molybdate is helpful.
- Applying sodium molybdate to soil @150 mg/m^2 will help to correct the deficiency symptom.
- Foliar spray of sodium molybdate solution of 1gm/lit may result in fast correction of the deficiency.
- Although symptoms of molybdenum deficiency are not easily distinguishable, leaf tissue analysis is a dependable diagnostic tool.

Zinc (Zn)

Zn deficiency occurs in cold wet soils, low in organic matter and highly leached/soil having high pH (pH>7.0)/ Soils high in P/exposed subsoil.

Deficiency symptoms

- Symptoms initially seen on lower leaves and later are seen on old and new leaves.
- Leaf size and stem length is reduced.
- This short internode cause the top of the plant to grow bushy.
- Plant shows a slight interveinal mottle on the lower leaves. Later this symptoms spreads up the plant.
- Little leaf formation is most important characteristics of zinc deficiency. Younger leaves may become abnormally small and necrotic.
- Stunted growth and dwarfing are the characteristics of zinc deficiency
- On prolonged deficiency, dead spots will develop all over the leaf.
- Intervenial yellowing on young leaves.

Zn deficiency

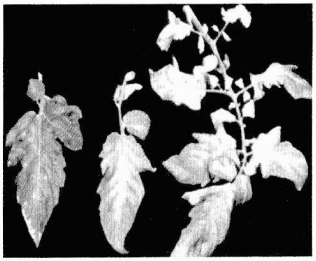


Fig.43 Plant shows a slight interveinal mottle on the lower leave

Fig.44a. Little leaf formation

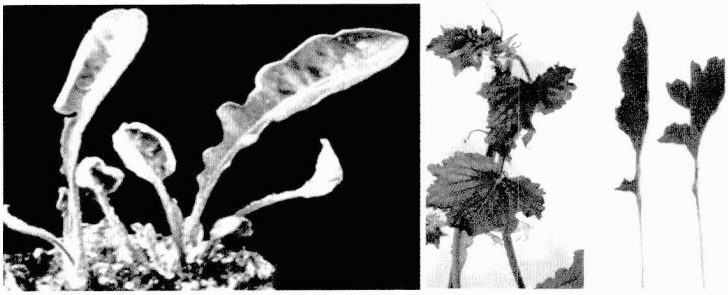
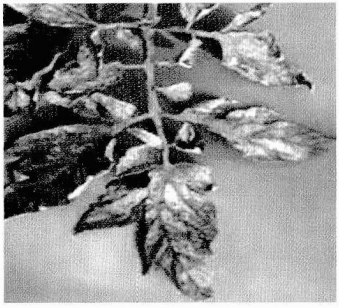
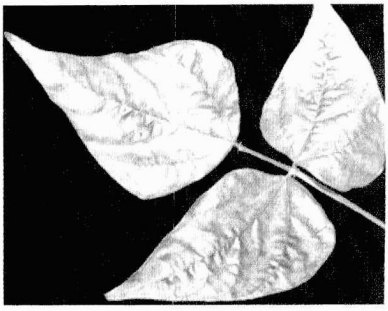


Fig.44b.Little leaf formation



Tomato

Fig.45.On prolonged deficiency, dead spots will develop all over the leaf



Yard long bean

Fig.46. Leaves become yellow green to yellow except veins

- On severe deficiency, overall growth is restricted and the leaves become yellow green to yellow except veins, which remain dark green and well defined.
- Flowering, fruiting and maturity can be delayed, shoots may die off and leaves found to fall prematurely.

Remedy

- $ZnSO_4$ has to be used for soil as well as foliar application.
- For 1000 sqm greenhouse, 1.5 kg to 3 kg of $ZnSO_4$ has to be added in the soil.
- In case of foliar application, use a mixture of 0.5% $ZnSO_4$ and 0.25% of lime.

Boron (B)

B deficiency occurs in coarse-textured low organic matter soils due to excessive leaching . It may also occur in soils with pH>7

Deficiency symptoms

- Deficiency begins at terminal buds/shoot tips.
- Boron deficiency causes both leaf and fruit symptoms.
- Plant growth get retarded & the leaves turn yellow or red.
- Young, expanding leaves may be necrotic or distorted followed by death of growing points .
- Internodes may become short, especially at shoot terminals.
- Yellowing on the tips of mature leaves gradually spreads around the margins and the veins become reddish-brown.
- Stems may be rough, cracked, or split along the vascular bundles.
- Young fruit will die or abort at high rates or deformed .
- Twisting & scarring can be seen at center and bottom.
- Corky areas develop near the calyx or on the shoulders of the fruit when plants seriously deficient in B.

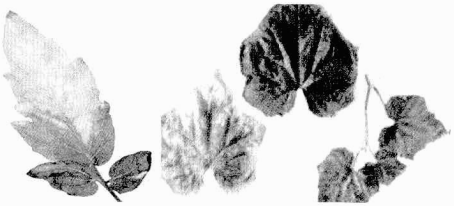
- Abnormal and retarded growth of apical growing points.
- Older leaves become thick, curl and become brittle
- Premature wilting and in acute cases, causes dieback of the growing tips.
- Stunted root growth.
- Broad yellow margin of the older leaves
- Boron deficiency is often found to be associated with sterility & malformation of reproductive organs and hence they produce sterile flowers.
- Sometimes *Choanephora cucurbitarum* and boron deficiency may get confused .

Remedy

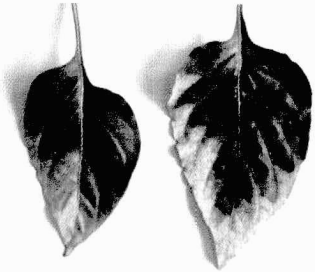
- Use 1 kg borax for 1000 sqm greenhouse before planting or 0.2% borax for application in soil.
- At pre-bloom stage of crop, a foliar spray of 0.1%-0.2% borax or sodium borate is beneficial.
- Rate of application must be monitored carefully because boron toxicity can cause severe plant damage.

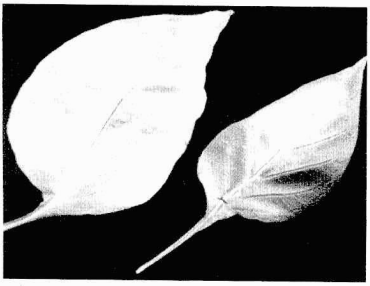
B deficiency

a. Tomato



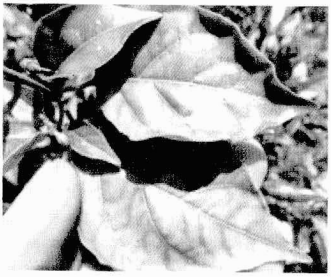
b. Salad cucumber



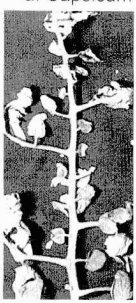


c. Capsicum

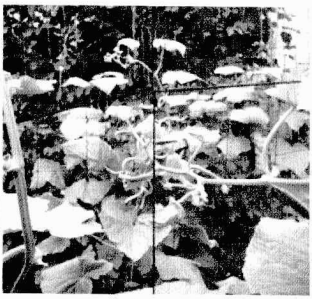
Fig.47 a.b.c. Plant growth is retarded & the leaves turn yellow



a. Capsicum



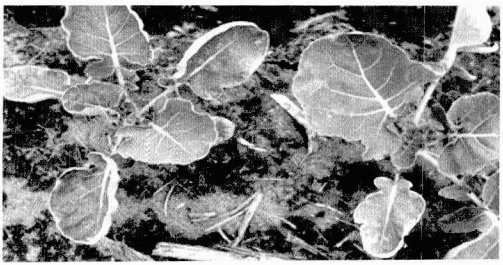
b. Tomato



c. Cucumber

B deficiency

d. Gerbera



e. Cabbage

f. Cauliflower

g. Chinese cabbage

Fig.48 a,b,c,d,e,f,g,Short internode length at shoot terminals and leaves become necrotic or distorted and caused death of growing points

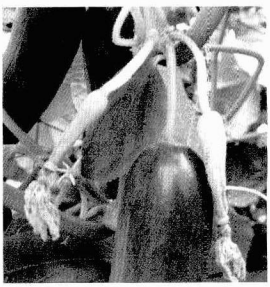
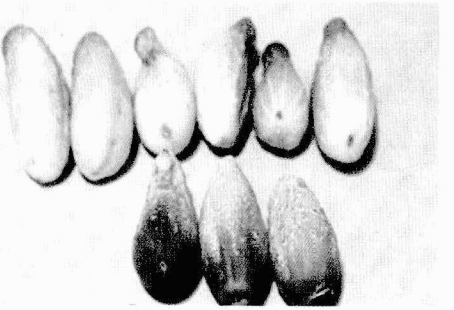
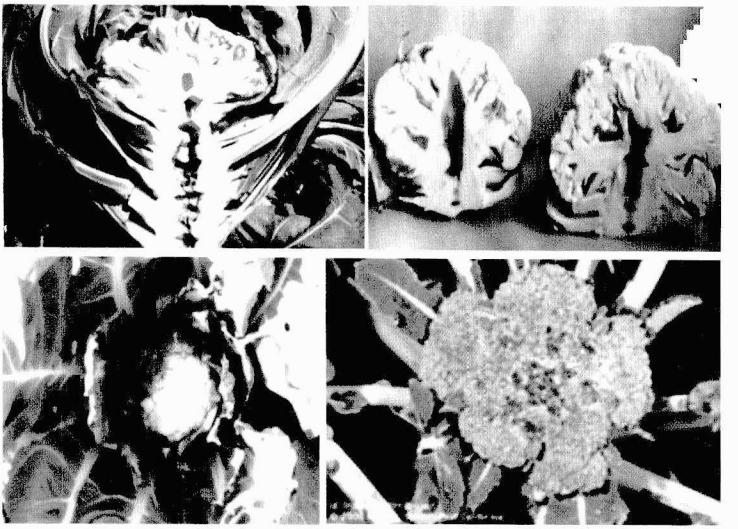


Fig.49. Young fruit will die or abort at high rates

B deficiency



a. Salad cucumber

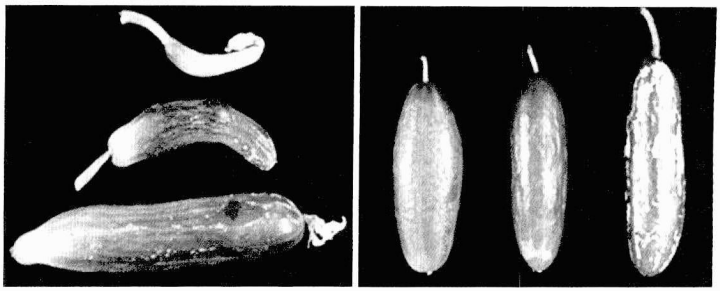


b. Cauliflower

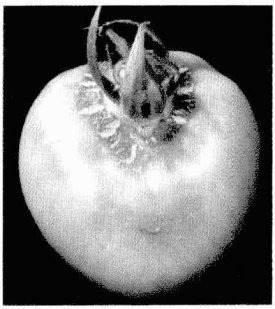
Fig.50.distorted fruits

Fig.51a. Twisting & scarring at center and bottom

B deficiency



a. Salad cucumber



b.Tomato

Fig.51b.Corky marking on the skin

a. Boron deficiency b. Choanephora cucurbitarum

Fig.52 Boron deficiency and Choanephora cucurbitarum

Iron (Fe)

Iron deficiency can occurs in poorly drained soils (poor aerobic soil conditions resulting from over watering) / low organic matter soils/soils with pH>7.0/ soils high in Phosphorous. In Calcareous soils, iron deficiency may occur (lime induced chlorosis). High level of manganese and poor root growth may also causes iron deficiency

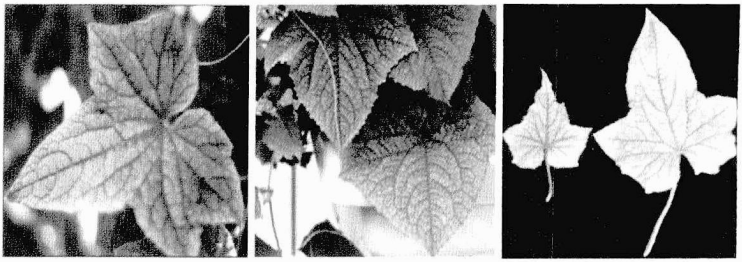
Deficiency symptoms

- Begin on younger leaves and are rare on mature leaves.
- A uniform pale green chlorosis of the newest leaves and all other leaves remain dark green.
- Initially, the veins remain green contrasting against yellow background, which gives a net like pattern. If the deficiency is severe, the minor veins also fade.
- On progressive deficiency, the leaves become almost pale white due to loss of chlorophyll.
- Under severe deficiency, leaves become dry and papery and may latter turn brown and necrotic. Complete leaf fall may occur and shoots can also die.
- Leaf mottling, bleaching and scorching of leaf margins are also found to occur.

Remedy

- Provide drainage facility to ensure proper aeration in the soil/media.
- Provide foliar spray of 0.4 % ferrous sulphate + 0.2 % lime or 0.5% $FeSO_4$ + 0.1% citric acid + 0.2% urea or iron chelates.
- In the case of soil application for 1000 sqm greenhouse, 1 kg of iron sulphate has to be added.

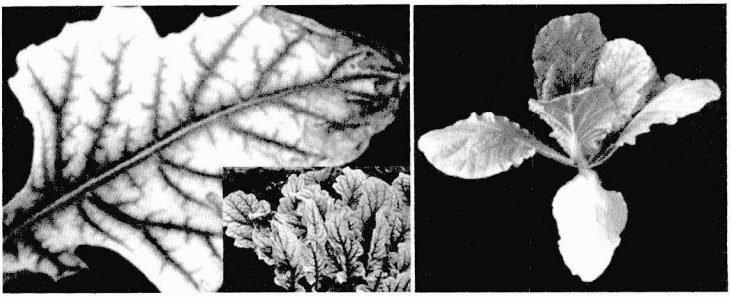
Fe deficiency



a.Salad cucumber

b. Yard long bean

c. Tomato

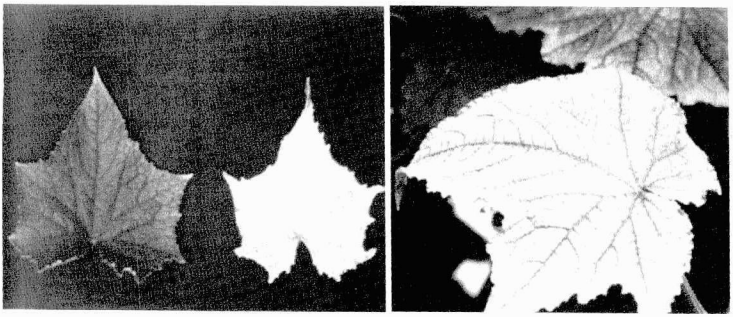


d. Gerbera

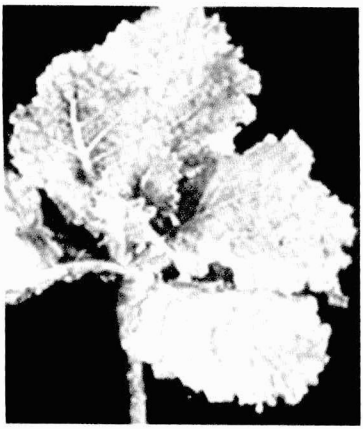
e. Chinese cabbage

Fig.53a,b,c,d,e.Veins remain green contrasting against yellow background makes a net like pattern. Under severe deficiency, the minor veins also fade

Fe deficiency



Salad cucumber



Cabbage

Tomato

Fig.54. On progressive deficiency, the leaves become almost pale white

Sulphur (S)

Deficiency symptoms

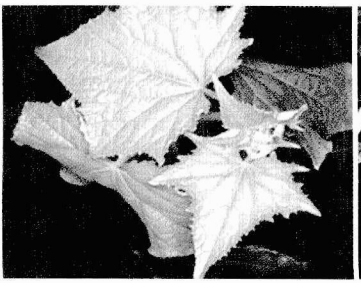
- Deficiency of this element is rarely a problem because it is present in many of the fertilizers as a carrying element.
- Sulphur plays a key role in plant metabolism. Hence Sulphur deficient plant produce less protein and oil.
- Slow growth of plants with slender stalks.
- The fruits may become light green, mis-shaped, thick skinned and less juicy
- Nodulation in legumes become poor and hence, nitrogen fixation get reduced.
- Orange or reddish tints may develop on older leaves and shed prematurely. The stem and leaf petioles become brittle and may collapse

- Sulphur deficiency resembles nitrogen deficiency. Unlike nitrogen, sulphur deficiency symptoms usually appear first on the youngest leaves and persist even after nitrogen application
- Chlorosis of young and most recently formed leaves and size gets reduced.
- Leaves become light green, followed by yellowing and shows poor spindly growth. Roots and stem become abnormally long.
- Yellowing of young leaves leads to orange/purple.
- Curling of margin, leaves become small.
- Reduced plant growth with slender stalks.
- Plants become rigid and brittle
- Suppression of fruit formation
- Rapid leaf fall.

Remedy

- Apply gypsum (25-50 Kg/1000 sqm) in the soil.

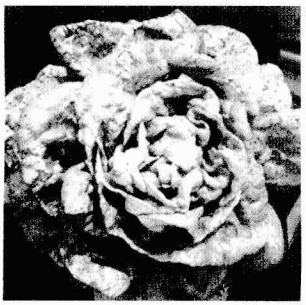
- Foliar application of sulphur or sulphate can eliminate the problem.
- Sulphur spraying / dusting is allowable only in those green houses covered with UV stabilized sheet having anti-sulphur property.



a. Salad cucumber

b. Capsicum

c. Tomato



d. Lettuce

e. Cabbage

Fig.55. Sulphur deficiency

Copper (Cu)

Cu deficiency occurs in Peat and muck soils/soil having high pH/ sandy soils/soils heavily fertilized with N. Copper deficiency will be also induced by heavy liming and excessive application of nitrogen and phosphorus.

Deficiency symptoms

- First appear in newly developed leaves
- The leaves eventually turn dull green or bronze, their edges turn down, and the plant remains dwarf . Moreover, bud and flower development at the top of the plant decreases.
- Drastic reduction in yield (by 20-90%). Few fruits that developed on the plant will be of small size and poor quality with sunken brown areas scattered over their yellow-green skin. The fruits are sometimes subjected to cracking.
- Plant shows chlorosis, often distortion and withering of the terminal leaves.
- Plants show restricted growth, short internodes and little leaves.
- Multiple bud formation in leaf axil and malformation of leaves is one of the common deficiency symptoms of copper.
- Burning leaf margin
- Older leaves show intervienal chlorosis.

Remedy

- Every 3-4 year, 0.2 - 0.6 kg of $CuSO_4$ has to be added in the100 sqm seed bed of greenhouse.
- Foliar spray of a mixture of 0.1% $CuSO_4$ and 0.05% lime and by controlling pH of the soil by adding 0.5% of $Ca(OH)_2$.

Cu deficiency

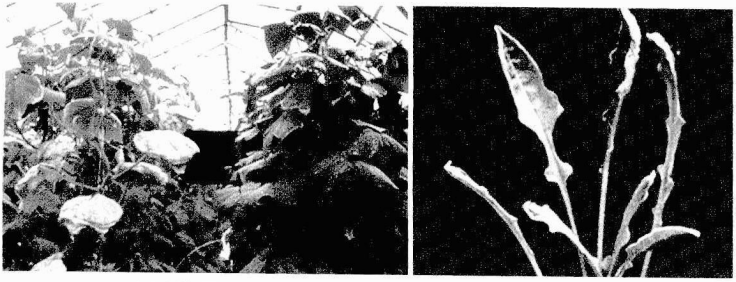


Fig.56. The leaves eventually turn dull green or bronze, their edges turn down, and some times plant remains dwarf.

Fig.57. Plant shows chlorosis, distortion and withering of the terminal leaves

Fig.58. Copper Deficiency due to over application of high biogas slurry

Nutritional Toxicities

Nitrogen (N)

Toxicity symptoms

- Plant shows dark green colour.
- Excess vegetative growth of plant.
- Strong thick stems, curled leaves in the head of the plant, large clusters and flowers, and poor fruit set.
- Plant is highly susceptible to pest and disease infestation.
- Wilting and downward cupping of the middle and older leaves, followed by yellow and brown burnt/scorching areas on lower leaves.
- Spots may occur between veins or at edges which will turn to yellow and then brown.

Remedy

- Leach the soil or growing medium with fresh water to remove excess fertilizer.
- Apply fertilizer only upto the crop needs.

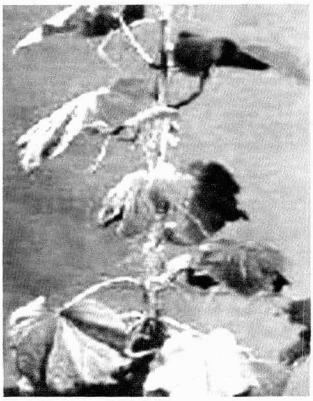


Fig 59. Nitrogen toxicity - shows wilting and downward cupping of older leaves followed by yellow and brown burnt areas on lower leaves

Phosphorous (P)

- Toxicity of 'P' may leads to iron chlorosis and deficiency of zinc.
- Phosphorus toxicity is not common in soil-grown crops.

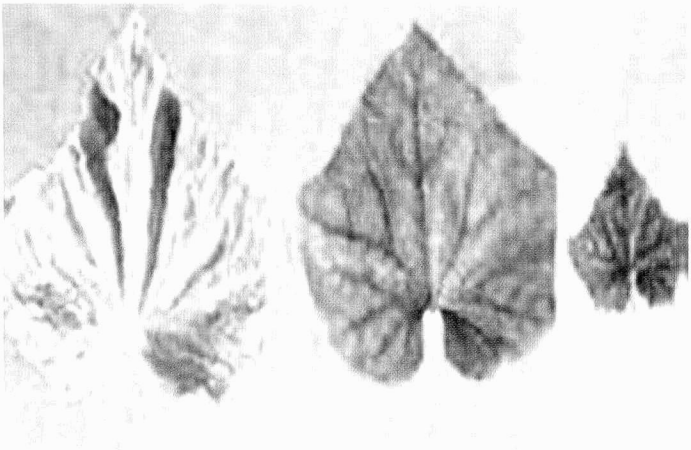


Fig.60.Phosphorous toxicity

Potassium (K)

- Potassium toxicity causes deficiency of magnesium as well as calcium.

Calcium (Ca)

- Excessive Ca may be problematic when growing cucumbers on calcareous soils.
- High Ca in the soil usually causes high pH which then precipitates many of the micronutrients. So they become unavailable to the plant.
- It may also interfere with Mg absorption.
- Toxicity of 'Ca' may leads to iron chlorosis.

Magnesium (Mg)

Mg toxicity observed in alkali soil .Higher concentration of Mg causes unbalancing of 'Ca' & 'K' and reduces plant growth.

Sulphur (S)

High sulphur levels can become sources of excessively high salts and could also be detrimental to the uptake of molybdenum.

Boron (B)

Toxicity symptoms

- Boron toxicity symptoms usually seen in older leaves, including yellowing between the veins followed by small brown necrotic spots and large areas of dead tissue.
- Leaf tips become yellow followed by necrosis.
- Newer leaves will also become chlorotic and get distorted.
- Reduced formation of female flowers .

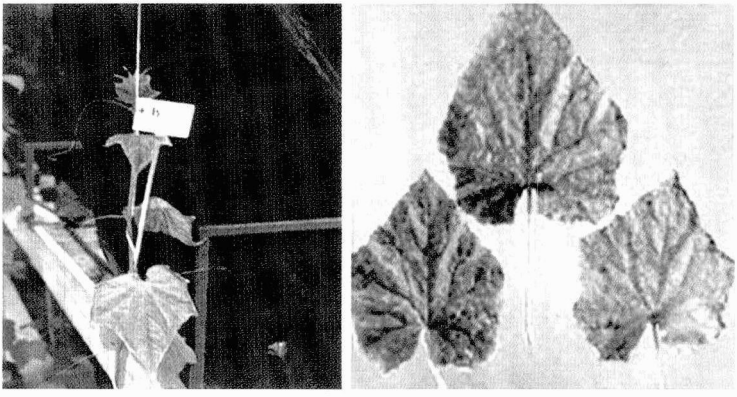
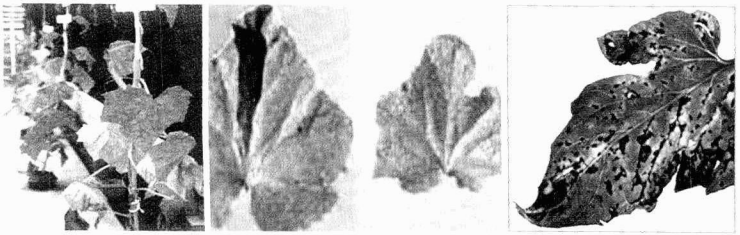


Fig.61.Boron toxicity - yellowing between veins followed by necrosis

Zinc

Toxicity symptoms

- Leaves become pale-green and chlorotic.
- Young leaves will become Yellow
- It may cause iron deficiency in plant.
- Rolling of some leaves.
- Clustering of leaves at the top.
- Zinc toxicity in cucumber leaves causes pale green chlorosis in young leaves which later become yellow.



Salad cucumber Tomoto

Fig.62.Zn toxicity

Fig.63.Zn & Mn overdose in salad cucumber

Iron (Fe)

Toxicity symptom

- Reduction in growth & browning of roots.
- Browning of leaves with tiny brown spots.

Copper (Cu)

- Excess copper decreases iron concentration in leaf.

Manganese (Mn)

Mn toxity observed in highly acidic soils and also in soils having poor drainage. Mn toxicity may induce Fe deficiency.

Toxicity symptoms

- Young foliage become light green, crinkled and necrotic. Older leaves often shows numerous small, reddish brown spots between the veins and on leaf petioles. After some time, the tissue around each spot becomes chlorotic & leaves become pale.

Remedy

Improve drainage & follow proper irrigation scheduling.

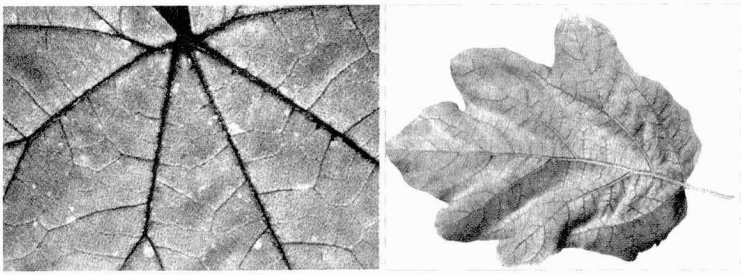


Fig.64. Mn toxicity

Molybdenum

Toxicity symptoms

- Plants can take up high levels of molybdenum without harmful effects on growth.
- Toxicity develops brilliant tints.

- Intense yellow or purple color in leaves may be rarely observed.
- There might be concern for human health with high molybdenum levels in the produce.

Chlorine (Cl)

Chlorine is usually present in town water supplies and also in some fertilizers such as muriate of potash (KCl).

Toxicity symptoms

- Reduces plant vigour
- Shows yellowing & scorching of leaf tips / margins.
- Premature yellowing and leaf fall.
- Chlorosis and overall wilting of younger leaves,
- The chloride anion reduces plant vigor and tends to accumulate in the leaves margins, producing a band of pale green tissue around the leaf margin with some leaf edge scorching and necrosis (tissue death).

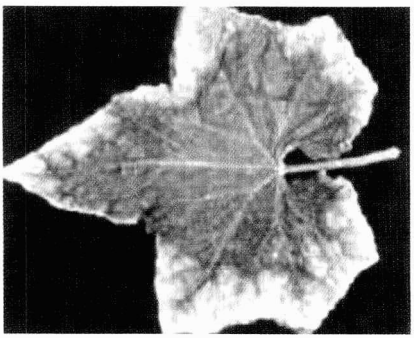


Fig.65.Chloride toxicity - A band of pale green tissue around the leaf margin with some edge scorching (associated with 3% chloride in tissue)

Remedy

- Salad cucumbers are moderately sensitive to chloride.
- Water quality has to be checked regularly.

- Take appropriate steps to find out the source of chloride and to avoid the source.
- Avoid potassium chloride if salt is a problem. Use Potassium fertilizers except Pottassium chloride.

Sulphur (S)

Toxicity symptoms

- Excess of sulphur causes premature dropping of leaves.
- Intervenial yellowing & burning of plant tissues.

Spots on the Fruits

Spots on fruits may happens due to high temperature and high light intensity in the summer months. It will also happen while applying high levels of nitrogen and spraying wrong combination of insecticides / fungicides or foliar grade fertilizers when the leaf and fruit temperatures are high.

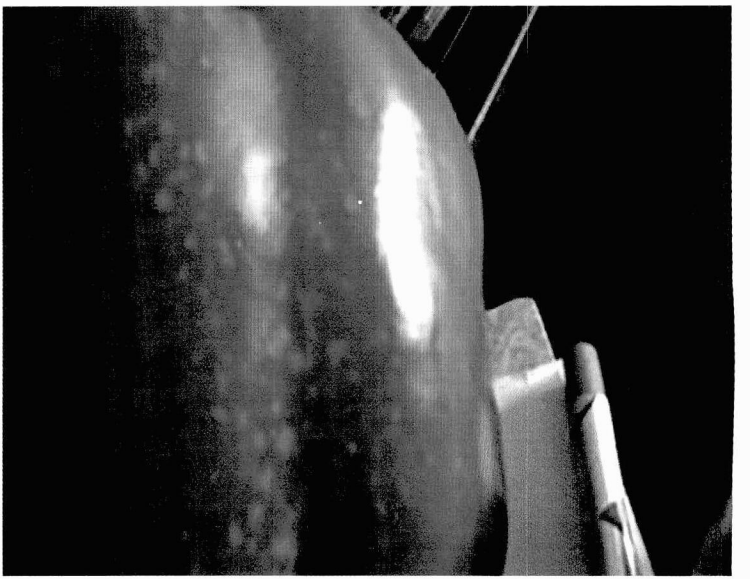


Fig.66 Spots on Capsicum

Sunscald or sunburn

When the intensity of solar radiation is very high it may cause sun burn on fruits or leaves of plant .

Remedy

Spread 35 to 50% shade net when the intensity of solar radiation is high to protect the plant.

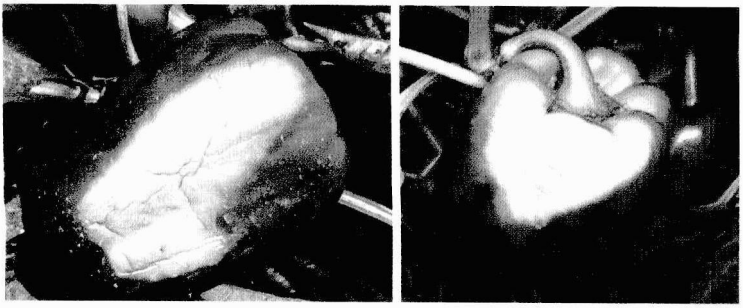


Fig.67 Sunburn in Capsicum

Cracking due to physiological disorder

Fruit crack may occur when plant is under gone water stress. Care must be taken to regulate the irrigation and to avoid temperature and humidity stress to the plants.

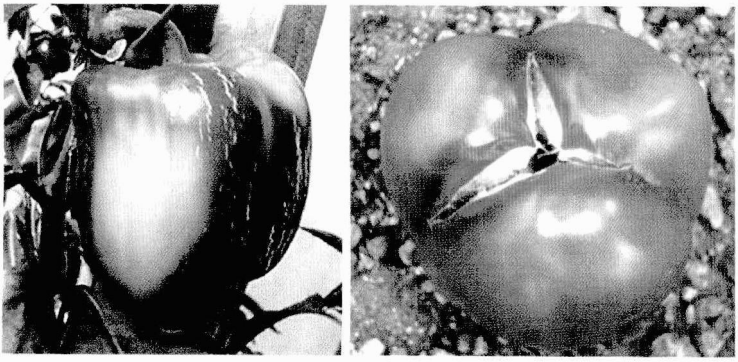


Fig.68 Fruit crack in Capsicum

High salinity / EC

EC /salinity damages may be caused by high E.C. of irrigation water / soil / growth medium and also by excessive application of fertilizers. Strong nutrient solution causes salinity in growing substrates.

Symptoms

- Leaves appear dark green, dull and leathery .
- A narrow yellow border develops around the leaf margin.
- Yield reduction of about 17% for a 1mmhos/cm increase in the E.C
- Affect leaf expansion and causes slight downward cupping
- By using water having high EC for foliar spray, leaf chlorosis and necrosis will occur

Remedy

- Leach the soil or growing medium with fresh water until the excess fertilizer is removed.
- Adjust the fertilizer program to ensure that rates do not exceed crop needs.
- Use cultivars that are more salinity resistant.
- Apply abundant amounts of potassium fertilizer, other than potassium chloride, as potassium markedly enhances plants ability to cope with salinity stresses.
- Avoid use of muriate of potash (potassium chloride)

High salinity

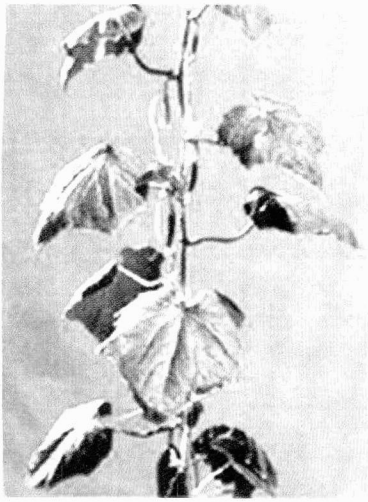


Fig-69. Leaves become dull and leathery

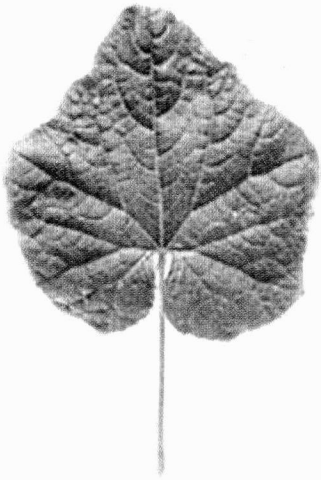
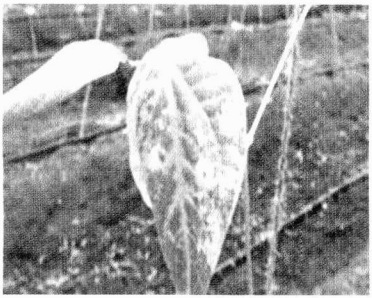


Fig-70. Narrow border develops around leaf margin



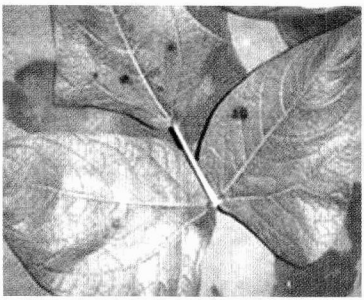
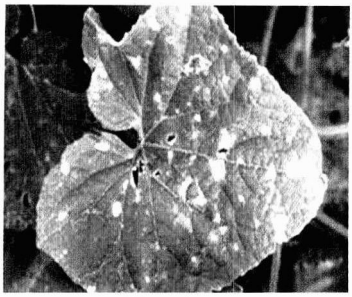


Fig.71. High acidity-causes iron and aluminium toxicity

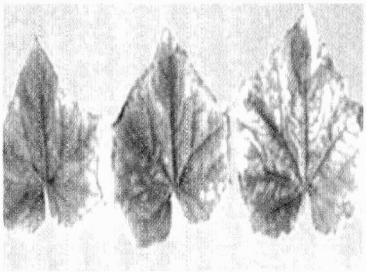
Nutrient deficiency symptoms in various crops

Salad cucumber

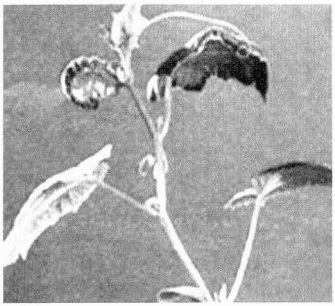
Nitrogen



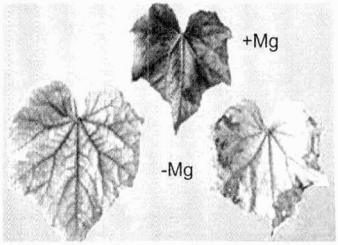
Phosphorus



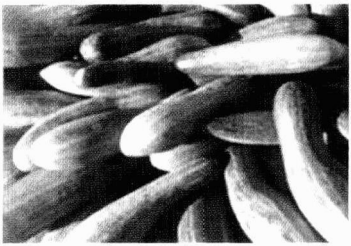
Potassium



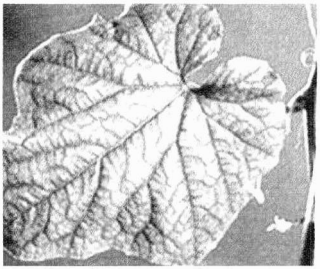
Calcium



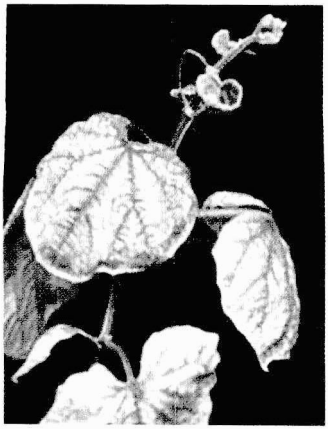
Magnesium



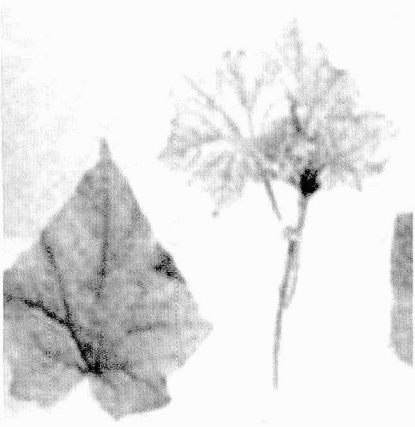
Calcium



Manganese

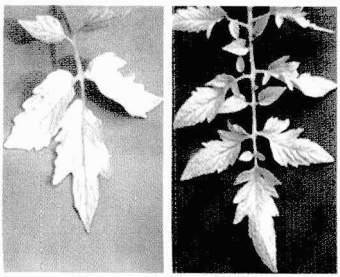


Boron

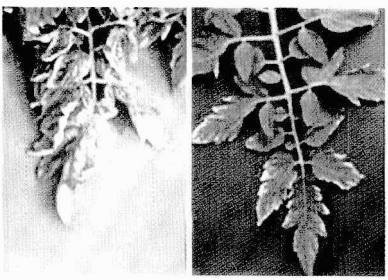


Iron

Tomato

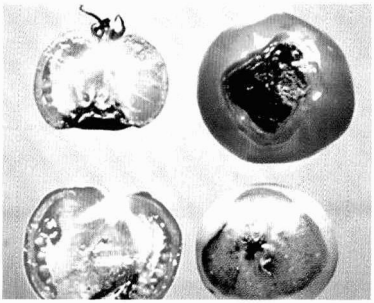


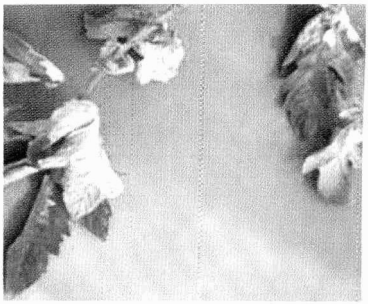
Nitrogen



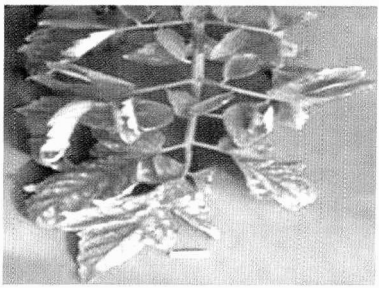
Potassium

Phosphorus

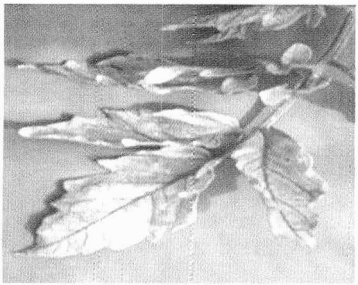




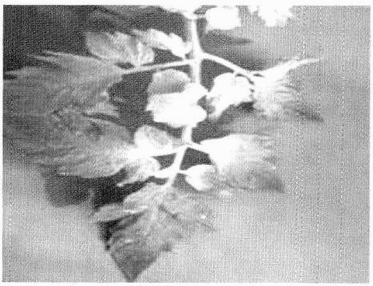
Calcium



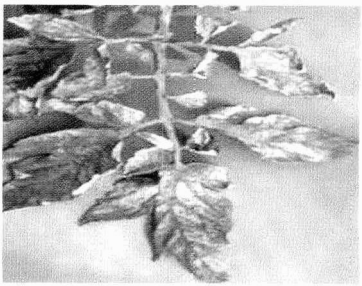
Magnesium



Sulphur



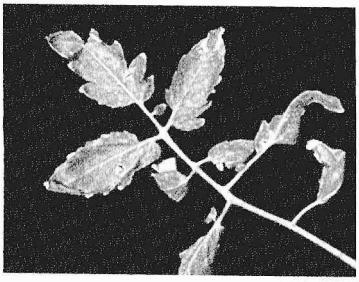
Iron



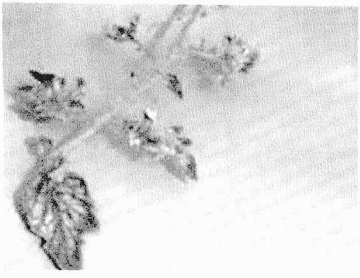
Zinc

Molybdenum

Manganese



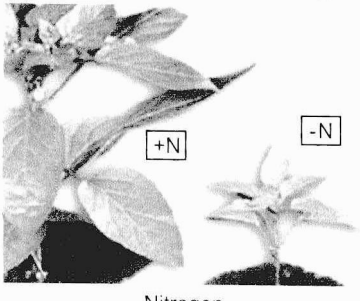
Boron



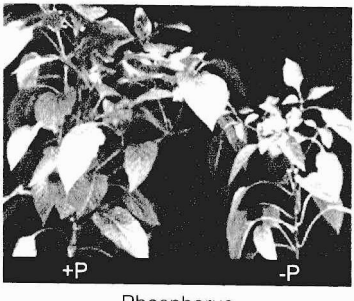
Chlorine

Copper

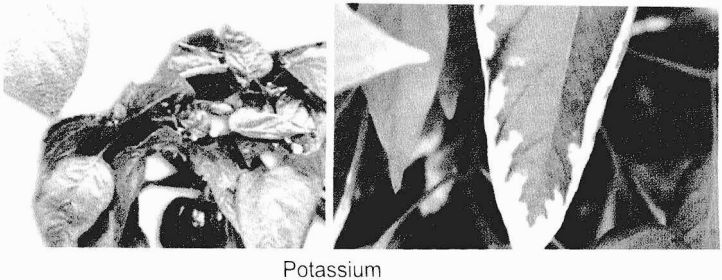
Capsicum



Nitrogen



Phosphorus



Potassium

Calcium

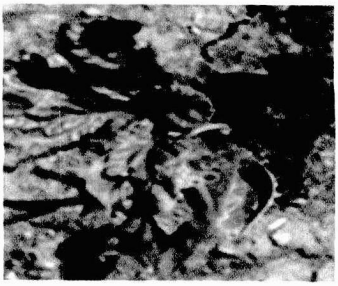
Magnesium

Sulphur

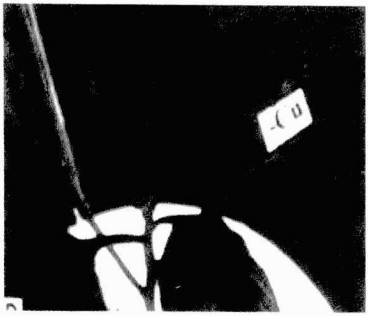
Iron

Zinc

Manganese



Boron



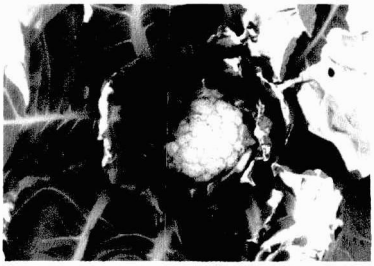
Copper

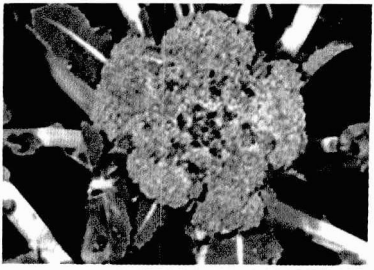
Cauliflower

Nitrogen

Phosphoreus

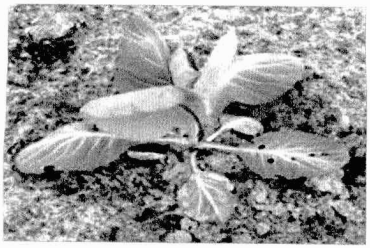
Molybdenum





Boron

Cabbage



Nitrogen

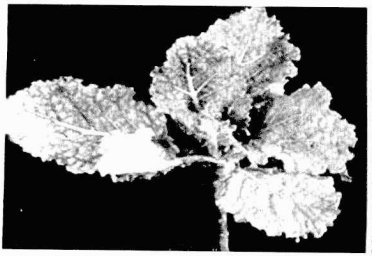
Phosphorus

Potassium

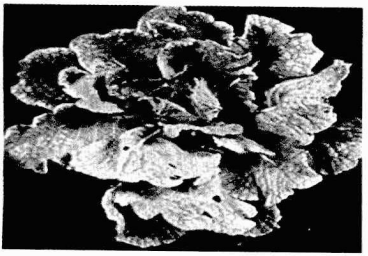
Calcium

Magnesium

Sulphur



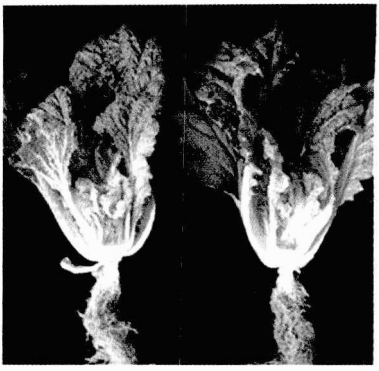
Iron



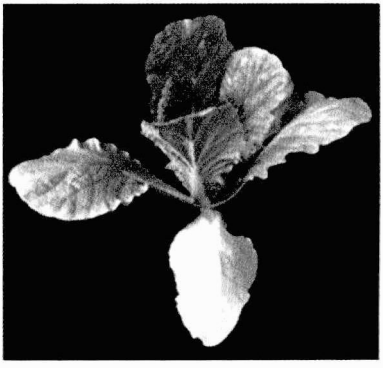
Manganese

Chinese cabbage

Calcium

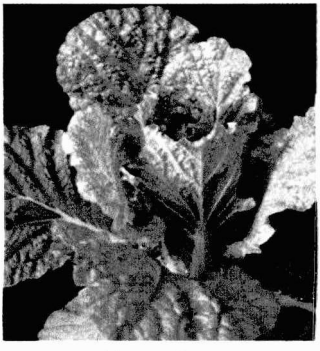


Boron



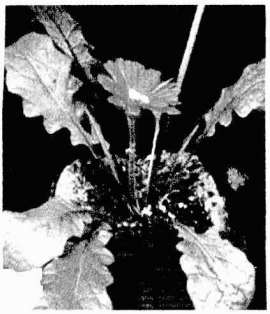
Iron

Potasium



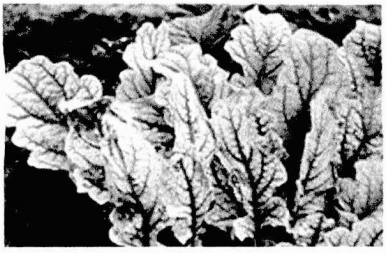
Magnesium

Gerbera



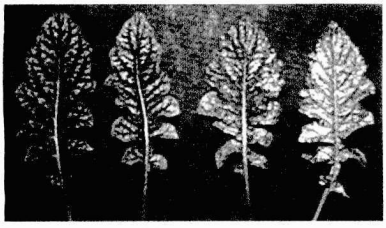
Nitrogen

Phosphorus



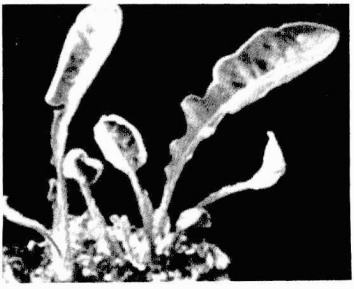
Iron

Zinc



Manganese

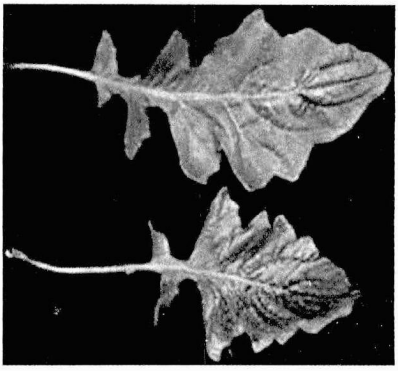
Copper



Boron

Boron

Molybdenum



Magnesium

Calcium

Iron