CHAPTER-II

REVIEW
OF
LITERATURE
Vegetable crops belonging to family Cucurbitaceae have a world wide distribution. The kind of plant varieties grown in a particular region depends on the agro-climatic factors of that part. Cucurbits are a good source of several vitamins, minerals and other useful components which are required for body growth and development. Vegetable are usually infected with various disease agents like fungal, bacterial and viral, resulting in severe losses in yield. A number of different virus strains have been reported which are pathogenic on cucurbits and have been reported to attack the crop naturally. Symptoms caused by different viruses, frequently are similar. Therefore, it is not possible to identify cucurbit viruses with certainty on the basis of symptoms alone. Sometimes, symptoms mislead because the same virus may produce different types of symptoms on different hosts and different viruses may produce similar symptoms on a host plant. This diversity in symptoms depends on virus host interaction, external conditions and stage of development of host. Usually, special laboratory and greenhouse studies are necessary to provide accurate virus identification. Out of different viruses infecting cucurbits, Cucumber Mosaic Viruses (CMV), Watermelon Mosaic Virus (WMV), Squash Mosaic Virus (SqMV) and Melon Mosaic Viruses (MMV) seems to be most prevalent.
(A) Important Viruses of Cucurbits:

Several viruses which may be grouped under the heading cucurbit viruses viz., cucumber mosaic, watermelon mosaic, squash mosaic, wild cucumber mosaic and cucumber necrosis have isolated from different cucurbits. The viruses have been characterized on the basis of their host range, physical properties, serological reaction and particle shape and size, etc. Watermelon mosaic virus has been further divided into different strains namely WMV I and WMV II on the basis of slight differences in host range and host reactions (Anderson, 1954).

Besides these viruses, several other viruses viz., tobacco mosaic, tobacco ring spot, aster yellow, curly top and cucumber green mottle mosaic virus (cucumis virus 2), yellow vein mosaic virus, watermelon mosaic virus, melon mosaic virus and squash mosaic virus have been isolated from several cucurbits by different workers. Extensive survey of Balrampur and its surrounding areas revealed that almost all the cucurbits and infected with cucumber mosaic virus (CMV). Important viruses that cause cucurbit diseases in nature are reviewed here along with their management.

1. Cucumber Mosaic Virus:

It is a member of Cucumovirus. Cucumber mosaic virus (CMV) was first identified by Boolittle (1920). Like tobacco mosaic
virus, this virus exists in a number of allied strains, some of which produce symptoms very different from those characteristic of the type virus. Cucumber mosaic is world wide in distribution, especially in temperate regions. CMV was most important on cucumber and caused severe reduction in yield and fruit quality. Another cucumovirus is Tomato Aspermy Virus (TAV), first described in 1946. This virus was so named, although, it is a common virus of Chrysanthemum (Hollings, 1956) because it was first described from diseased tomato plant growing near Chrysanthemum in a garden. This virus is known by both names: Tomato Aspermy Virus (TAV) and Chrysanthemum Aspermy Virus (CAV). Peanut Stunt Virus (PSV), also called groundnut stunt virus (Mink, 1972) caused widespread disease in peanuts in 1960's Virginia. It is also now recognized as a member of cucumovirus group.

Host Range and Symptomatology:

Host range is wide; more than 34 families, including both dicotyledons and monocotyledons are susceptible to infection. Susceptible plants include annuals, several cucurbit vegetables, non-cucurbits agricultural crops, flowers and ornamentals, and several weeds. In addition to cucurbits, CMV also can infect tomato, limabean, better banana, sweetcorn, ground cherry, and sweet potato. On the basis of symptoms, cucumber mosaic is identified by the
presence of greenish areas and elongated spots on the affected leaves. Infected plants show stunted growth and the leaves become reduced to half of their normal size. In cucurbits, plants are rarely affected at the seeding stage. However, when they are cotyledons may become yellowish and wilt; new leaves may be slightly mottled; further growth is slowed; and new leaves remain small, wrinkled, and distorted with distinct mottling yellowish green. Such plants seldom produce fruits, usually are short lived, and rarely exceed a length of 12 inches. When vigorous cucurbit plants are infected at the 6 to 8 leaf stage, the first symptoms appear on the youngest leaves that are still expanding. Small greenish yellow areas appear on the leaf, the margin of the leaf may curl downward; the leaf surface becomes wrinkled with the tissues between the small veins becoming slightly raised; and finally, the leaves become distinctly mottled. All leaves, petioles, and stems formed after the first symptoms appear are dwarfed. With age, the wrinkled and saveled character of leaves may become more conspicuous, and the mottling may become less conspicuous. Such plants produced few fruits.

Transmission:

Mechanical Transmission:

The virus is easily transmissible by mechanical means. Several virologists successfully transmitted the various strains by mechanical
inoculation of sap (Peters and Derks, 1974; Vrma and Kumar, 1980; Honda et al., 1983).

The virus or its strains are readily transmissible by inoculation of sap to following diagnostic, propagative and assay species.

*Cucumis sativus*, *Nicotiana tabacum*, *Lycopersicon esculentum*, *Phaseolus vulgaris*, *Chenopodium amaranticolor*, *C. quinoa*, *Vigna sinensis*, *N. tabacum* cv. *Xanthi-ne* are suitable plants for maintaining cultures. *N. tabacum*, *N. clevelandii* and *Cucurbita pepo* are good source for virus purification.

The cucumber mosaic virus naturally infecting *Dianthus barbatus* and *Vaccaria pyramidata* and to other herbaceous test plants (Raj et al., 1993).

Cucumber mosaic virus causing mosaic disease of pea (*Pisum sativum* L.) was easily transmitted by mechanical method (Rao et al., 1995). Another new strain of cucumber mosaic virus isolated from chilli by Singh and Shukla (1990) was found to be transmitted mechanically. *Basella rubra* L. is reported additional natural host of cucumber mosaic virus (Gupta and Tewari, 2007).

**Insect Transmission:**

More than 60 species of aphids namely, *Myzus persicae*, *M. cincumflexus*, *M. ascalonicus*, *Aphis gossypii*, *A. rumicis*, *A. maidis*, *A. cordii*, *A. fabae*, *A. malvoides* and *A. craccivora* Koch. Are transmitted strains of cucumber mosaic virus from diseased to healthy palants (Govier,
1957; Singh and Shukla, 1990; Valverde, 1990; Rao et al., 1995; Singh et al., 1999; Kiranmai et al., 1998).

Virus can be acquired by different aphid species in less than 1 min. and inoculated in less than 1 min. Feeding vectors retain virus for less than 4 hrs. The virus in not transmitted to progeny aphids.

In case of VMY, using *M. persicae* as the vector for virus, the percentage of infection increased with increase in the number of insects used. No differences were observed in the relative efficiency of the various stages of aphids. The entire process of picking up the virus up to transmitting it to a healthy plant required a very short time, usually less than 30 min, there apparently being no incubation or latent period of virus disease of Lady's ice (*Pimpinaello monoica*) was inactivated 55-60°C, has a DEP $10^1-10^4$ and retained infectivity 6 for 5-6 days at $25 \pm 5^\circ C$. Okashi and Kamiunten (1994) reported mosaic disease of green *Amaranthus* caused by cucumber mosaic virus which had TIP in crude sap between 55-6°C, DEP $10^3$ to $10^4$, LIV 2-4 days at 25°C.

**Purification and Electron Microscopy:**

Cucumber mosaic virus has been purified using different procedures. One method involves homogenizing CMV infected tissue of cucumber or tobacco in buffer containing a reducing agent. The filtrate of the homogenate is clarified with n-butanol and the virus is
concentrated and partially purified by differential centrifugation. This is followed by acid precipitation and further differential centrifugation (Tomilson et al., 1959).

The second method involves grinding the infected tissue in 0.5 M citrate buffer (pH 6.5, containing 0.1% thioglycolic acid) together with an equal amount of chloroform. The aqueous phase is dialyzed against 0.0005 M borate buffer (pH 9.0). The virus is sedimented and clarified by three cycles of high and low speed centrifugation. The pellet obtained by high speed centrifugation is resuspended in borate buffer. The purification is done at 0-4°C (Scott, 1963).

Murant (1965) extracted tissue in 0.5 phosphate buffer (pH 7.5) containing 0.1% thioglycolic acid. The filtrate was shaken with an equal volume of ether and centrifuged at low speed. The virus was sedimented and clarified by two cycles of high and low speed centrifugation. The pellets obtained at high speed were resuspended in 0.06 M phosphate buffer (pH 7.5) and centrifuged at low speed. The supernatant fluid was adjusted to pH 5.0 and centrifuged again at low speed. The pellet was resuspended in 0.06 M buffer and centrifuged at low speed. The purification work is done at 0.4°C. Zone electrophoresis can also be used to free partially purified virus form host materials (Van Regenmortel, 1960).
Electron microscopy examinations revealed that CMV consists of spherical particles at 28-30 nm in diameter (Scott, 1960). A strain of CMV from squash gave average diameter of 25-26 nm (Van Regenmortel, 1960).

**Serology:**

Antiserum was produced by injecting rabbits intravenously or intramuscularly with purified CMV. The virus is poorly immunogenic. None of the antisera reacted at dilutions greater than 1/128 (Scott, 1960). An antiserum with a titer of 1/1024 was prepared from partially purified preparation (Tomlinson *et al.*, 1959). Specific precipitate of virus in serological tests in liquids is granular. In gel diffusion test, two bands of precipitates may develop when antisera prepared by intramuscular injection are used: a curved band near the antigen well (intact virus) and a straighter one nearer to the antiserum well (degraded virus). Antisera prepared by intravenous infection may react only with the slower diffusing antigen (Scott, 1968).

**Particle Composition:**

Cucumber mosaic virus contains 1.8% phosphate and 16.4% nitrogen. Its base ratio is adenine 24.3%, guanine 23.4%, cytosine 23.2% and uracil 29.1%. The RNA is 18.5%. The extracted RNA is highly infectious, single stranded with a mol. Wt. of about 1×10⁶. The
protein subunits have molecular weight of virus varies between 4.9-6.7 million Dalton (Kaper et al., 1965). Isoelectric point of the virus is 4.7.

Besides cucumber mosaic on cucumber caused by CMV, some other naturally occurring diseases attributed to cucumber mosaic virus are Banana mosaic, Calendual mosaic, Canna mosaic, Commelina mosaic, Cowpea mosaic, Eggplant mosaic, Maize stripe mosaic, Spinach blight, Tomato narrow leaf, Tree tomato mosaic, Vinca mosaic, Yacca ringspot and Zinnia mosaic, etc.

Control of Cucumoviruses:

CMV can be controlled by the use of different chemicals, plant leaf extracts, cultural practices and spraying with different insecticides.

Cucumber mosaic in vegetables and flowers can be controlled primarily through the use of resistant varieties, elimination of weed host, and control of the insects. Varieties resistant to CMV have been developed for several host crops, including cucumber and spinach.

Transport crops kept in greenhouse should be isolated from other plants such as geraniums, lilies and cucumbers that may harbor the virus, and when transplanted they should not be planted near early susceptible crops or near plots in which there may be weeds harboring the virus. Perennial weeds should be eradicated from around greenhouses, cold frames, greens, and fields to eliminate the
source of CMV likely to be carried to crop plants by insects or sap. Since most of the early virus infections are initiated by insects, early sprays with insecticides to control the aphid vectors before they carry the virus into young, rapidly growing plants have been very helpful. The rate of CMV spread may be reduced by handling and touch while working in plantings, plants should be handled as little as possible to minimize this chance.

Aluminium mulch is the reflective material most frequently used to control aphid borne viruses. The mulch repels aphid vectors, thus delaying virus infection; where needed. This treatment has resulted in doubling the yield in some cucurbits. Aluminum mulch keeps the soil temperatures under the mulch lower than desirable soil temperatures. The inner 50% of the exposed mulch surface should not be aluminium coated but should be black or clear. Black striped aluminium mulch is less effective in repelling aphids than is aluminium mulch without the black stripe.

Aphid vector control with insecticides has been tried, but is ineffective because the insecticides do not kill the aphids before they transmit the virus. It takes less than one minute for an aphid to acquire and transmit the virus.

The most effective method is the use of resistant varieties. This has been successful with cucumber since the 1940s. Resistant to
CMV still is needed for other cucurbits. Induction of resistance by certain phyto-antivirals appears to be very promising in preventing the virus infection.

**Symptoms Produced by Cucumber Mosaic Virus on Different Host:**

**Family- Cucurbitaceae:**

**Cucumis sativus, (Cucumber):**

The virus produces characteristic greenish areas as circular or elongated spots on the leaves. Plants become stunted with shortened. Leaves are reduced to half of their normal size. Fruits become deformed.

**Tricosanthes anguina L. (Snakegourd):**

On snakegourd (*Tricosanthes anguina* L.) the virus produces mosaic symptoms. Symptoms are characterized by mosaic pattern of irregular dark green and yellow chloritic patches on the lamina.

**Lagenaria siceraria (Bottlegourd):**

Symptoms are in the form of irregular light green and dark green mottling and occasionally yellow chlorotic area on the leaves.

**Cucumis moschata (Pumpkin):**

In pumpkin (*Cucumis moschata*) initially mosaic symptoms are produced but subsequently, blistering and green vein banding followed by complete chlorosis is also seen. Older leaves show prominent dark green raised blisters. Sometimes the leaves show chlorosis in veins and vein-lets, leaving interveinal areas green.
*Cucumis pepo* (vegetable marrow):

Vegetable marrow plant (*C. pepo* L.) shows typical mosaic pattern of light and deep green areas on the affected leaves and also reduction in leaf size. Flowering was delayed and fruits were small in size.

*Luffa acutangula* (Tori):

On tori (*Luffa acutangula*) the characteristic symptoms produced are light and dark green mosaic mottling, downward curling of leaf margins and general stunting of plant growth. Affected plants bear very few flowers and fruits.

*Citrullus vulgaris* Schrad (*Watermelon)*:

Symptoms are characterized by mild chlorosis, stunting, distortion, and mottling of leaves, Green bands along the veins or raised green blisters and wide chlorotic interveinal areas are also common.

*Cucumis melo* L. (*Muskmelon)*:

The symptoms observed are mosaic mottling of the leaves in the beginning. The younger leaves show complete chlorosis followed by green vein banding whereas the older leaves exhibit chlorotic symptoms and prominent dark green raised blisters on the lamina.
**Cucurbita maxima** (Squashes):

Young leaves develop extremely savored appearance, the dark part of the leaf being much more raised above the leaf surface. In the case of cucumber, the light spots on the leaf are pale yellowish-green.

**Family- Solanaceae:**

**Nicotiana tabacum** var. (White burley):

CMY produces two types of symptoms on white burley. Local lesions, produced on leaves, occur as pale circular spots on the inoculated leaves after 2-3 days. Systemic infection first produces slight clearing of the veins and this is followed by mild general mottling and distortion (narrowing) of the leaves.

**Nicotiana glutinosa:**

Mottling symptoms are sometimes severe. Dark green blisters are produced occasionally on the leaves. Sometimes the entire plant may show stunting.

**Lycopersicon esculentum** (Tomato):

CMV caused symptoms on tomato plant are known as ‘fern leaf’ symptoms where leaf lamina of the infected leaf is reduced or sometimes absent. Young leaves in a normal plant start to unfold at an early state. In CMV infected tomato, the leaves remain folded, curve downwards or curl up in spirals. Chlorosis of the older leaves is also common.
Raj et al., (1993) reported that cucumber mosaic virus naturally infected the *Dianthus barbatus* causing leaf crinkle and stunting of plants. They also mechanically transmitted this virus in *Vaccaria pyramadata* and to other herbaceous test plants.

Rao et al., (1995) found a new strain of cucumber mosaic virus causing mosaic disease of pea (*Pisum sativum* L.) which is easily transmitted by mechanical method through number of aphids from diseased to healthy plants.

Yanming et al., (1997) isolated a strain of CMV from spinach which is readily transmitted by *Myzus persicae* and through seed.

Kiranmai et al., (1998) studied the epidemiology of cucumber mosaic (*cucumovirus*) around Triupati and reported that the young leaves of infected Solanaceous vegetable crops curl downwards along the midrib and the basal portion of the leaf is frequently light green. The foliage becomes yellowish green and the leaves appear to be firmer in texture than those of healthy plants. Fruits are also infected with virus. They also reported the cucumovirus naturally infecting chill and the symptoms produced were chlorotic spotting mosaic, leaf puckering and malformation.

Sing et al., (1999) found a strain of cucumber mosaic cucumovirus causing mosaic in marigold and it is easily transmitted from diseased to healthy plant by aphids.
Metabolic Studies:

The entire metabolism of the host plant changes after viral infection i.e. possibly by changing the physiological and biochemical processes of plant. These changes may be the result of interaction of the virus induced synthesis of new proteins within the host, some of which remain biologically active substances capable of interfering with the normal metabolism of the host (Bawden, 1959; Dienner, 1963; John, 1963a; Sadasivan, 1963; Farakas and Solymosy, 1965; Opel, 1965; Bollared and Matthews, 1966).

In general, changes in physiology of cucurbit infected plants with virus have been studied by various workers (Bawden, 1959; Dienner, 1963; John, 1963a; Mundry, 1963; Kohler, 1964; Matthews, 1970). However, in India the work on physiology of virus infected plant has been limited such as Dolichos enation mosaic (John, 1963b), pigeon pea sterility mosaic (Narayanaswamy and Ramakrishnan, 1965; 1966a, b) tori mosaic (Mitra and Naraini, 1965), mosaic of chilli (Jeyarajan and Ramakrishnan, 1968, 1972; Singh and Awasthi, 1969), cassava mosaic (Alagianagalingam and Ramakrishnan, 1969), cowpea mossaic (Raddy and Chenulu, 1970), tomato leaf curl (Lodh et al., 1971), sugarcane mosaic (Bhargava et al., 1970), soybean mosaic virus (Suteri, 1974; Gupta, 1975), Pumpkin mosaic and pumpkin mild mosaic virus (Ghosh and Mukhopadhyay, 1979),
watermelon mosaic virus (Singh, 1983; Tewari et al., 1988), bottle

gourd mosaic virus (Tripathi, 1990), tomato mosaic virus (Giri and

Mishra, 1990), virus infection of pipper bettle (Johri et al., 1990),
cassava mosaic virus (Matthews and Muniyappa, 1990, 1993), rice
tungro virus infection (Anjaneyulu and Stapathy, 1992), berseem
mossic virus (Fugro and Mishra, 1993), mungbean mosaic virus (Vani
and Verma, 1993), mosaic virus of soybean (Ghosh and Dhingra,
1993), sterility mosaic pathogen of pigeon pes (Reddy et al., 1993),
mosaic disease of Sesbania grandiflora (Eranns et al., 1995), mung bean
yellow mosaic virus (Jayaraman et al., 1995), tobacco mosaic virus
(Patel and Patel, 1995), petunia mottle virus (Malik et al., 1996),
sorghum red stripe virus (Pawar et al., 1996), sterility mosaic disease
of pigeon pea (Zote et al., 1997) and benincasa mosaic virus (Sug,
1970; Tewari and Dixit, 2000, 2001; Pandey et al., 2003).

Moisture and Dry Matter Content:

Plethora of available literature indicates that there is a general
decrease in water content and increase in dry matter content due to
infection of host plant. Campbell (1925) reported that leaf roll
affected potato leaves had lesser moisture content and higher dry
matter content as compared to healthy ones. Watson and Watson
(1951, 1953) observed that water content of beet leaves infected with
beet yellows was decreased as compared to that of healthy leaves,
while mosaic infection had little or no affect on water content. Alagianagalingam and Ramakrishnan (1969) reported lesser moisture content in Cassava leaves infected with Cassava mosaic virus when compared to healthy ones.

In cowpea affected with mosaic, Reddy and Chenulu (1970) observed lesser water content in early inculcation which increased in the later stages. Srivastava (1971) reported that moisture content of sugarcane leaves, stem and roots whether taken from healthy or mosaic affected plants increased with age, but the samples taken from infected plants always had lesser moisture content and more dry matter content than the healthy ones. Jeyarajan and Ramakrishnan (1971) found that the loss in weight of potato virus Y infected leaves of chilli plants was greater than that in healthy leaves. Infected leaves showed reduction in moisture content and fresh weight/dry weight ratio. The rate of water uptake was faster in infected shoots than in healthy shoots. Joshi and Dubey (1975) reported that leaf, stem and root samples taken from cucumber mosaic virus infected chill plants, contained less moisture content and more dry matter than their comparable healthy counterparts. A decrease in moisture content and increase in dry matter content have been reported by Singh and Singh (1979) in sun hemp leaf, stem and root as influenced by common been mosaic virus.
Infection to various plants with same or variable viruses reveals some what different story in the metabolic profile of the plants as – Heuberger et al. (1933) found that at five leaf stage, the water content of tomato leaves inoculated with tobacco mosaic virus was higher than healthy ones. Ainsworth and Selman (1936) showed the water content of tomato seedlings inoculated with tobacco mosaic virus was lower than that of healthy ones in the early stage of infection, but during the later stage the water content increased over that of healthy.

Shukla (1985) observed reduced moisture content in case of Cucurbita maxima infected with watermelon mosaic virus in stem, root and leaf whereas an increased percent dry matter content in comparison to their healthy counterparts. Tripathi (1990) observed reduced moisture content in case of Cucurbita pepo L. infected with bottle gourd mosaic virus in stem, root and leaf whereas an increased percent dry matter content in comparison to their healthy counterparts.

**Chlorophyll Content:**

Virus affected plants exhibit various symptoms which are the result of their effects at the cellular and sub cellular level. Irregular pattern of yellow or green patches on leaves, mostly younger ones, generally known as mosaic is the most common expression, identifying the association of virus with plants. Mosaic viruses
produce an adverse effect of disturbing the photosynthetic tissue of the host plant. However, the change of colour in infected plants makes it clear that the chlorophyll is either destroyed or not synthesized at the same rate as in healthy ones. The absence of chlorophyll in such case has been attributed to the inhibition of formation of new plastid units rather than the destruction of the existing ones.

Less chlorophyll content per plastid was observed by Dickson (1922) in light green areas of tobacco leaves affected by mosaic disease. Sorobin (1926) demonstrated that tomato mosaic was accompanied by a progressive disintegration of chloroplast. These chloroplasts were also smaller in size in mosaic affected plants. Dunlap (1928) found lesser chlorophyll (a and b) content in tobacco affected by mosaic disease than the normal ones. Peterson (1931) observed that the chlorophyll content was lower in tobacco leaves affected with three types of tobacco mosaic virus causing mild dark green, light green and intense yellow mosaic. Peterson and Mckinney (1938) reported reduced chlorophyll content in tobacco leaves showing mosaic symptoms than the healthy ones. According to Chono and Rafay (1950) there was twenty percent less chlorophyll in sugarcane leaves infected with sugarcane mosaic virus than healthy ones before monsoon but after this season both healthy and infected
leaves contained almost nearly equal amount. John (1963a) observed reduction of chlorophyll in leaves of tobacco and tomato infected with tobacco mosaic virus.

Decrease in chloroplast protein in pigeon pea was observed by Narayanaswamy and Ramakrishnan (1965a) infected with sterility mosaic virus. Srivastava (1971) recorded a decrease in the chlorophyll content of sugarcane leaves infected with sugarcane mosaic virus. Chaudhury and Mukhopadhyaya (1974) noticed decrease in chlorophyll of the entire three virus infected varieties of rice (Jaya, Padma and IR-8). Tripathi (1990) observed chlorophyll content was reduced in Cucurbita pepo L. infected with BGMV. Malik et al., (1996) reported the infected plant showed low chlorophyll content in the leaves of Petunia infected with Petunia mottle virus.

**Enzymatic Activity:**

Various research workers worked on different virus host combinations and recorded the enzymatic activities of various enzymes in normal and virus infected plant tissues, with effective differences. Presumably virus infection alters the amount of enzyme present in the host. Certain enzymes are activated within the host as a defense mechanism against the parasite while other enzymes act to serve as its own end.
Peroxidase Activity:

Increase in the activity of peroxidase in virus infected plants has been observed by various workers (Orlab and Arny, 1961; Lobenstein and Linsey, 1966; Joshi and Dubey, 1976; Upadhyays, 1981; Shukla, 1985; Singh and Singh, 1986) while initial decreased peroxidase activity was observed by Wynd (1942) followed by an increase and then decrease in the activity of enzyme showing a fluctuating trend at various intervals in the mosaic infected tobacco plants. Variable peroxidase activity was recorded by Hills and Mokinney (1942) in both resistant and susceptible varieties of mosaic infected tobacco plants where it was partially declined in resistant plant than susceptible ones. Narayanaswamy and Ramakrishanan (1965b) pointed out that this enzyme was inhibited in pigeon pea leaves affected with pigeon pea sterility mosaic virus. Kato and Misama (1972) observed that peroxidase activity show an initial rapid increase after inoculation of cucumber mosaic virus in tobacco tissues but returned to control level after four hours.

Tripathi (1990) observed increase in peroxidase activity in comparison to their healthy counterparts in case of Cucurbita pepo L. infected with BGMV. Upadhyaya and Srivastava (1996) also reported the increased peroxidase activity in mung (Vigna radiata L.) infected with green gram mosaic virus.
Catalase Activity:

Several workers reported, both enhanced and reduced catalase activity in virus infected plants. Increased catalase activity was reported in sugarcane infected with sugarcane mosaic virus by Yamfugi et al., (1943), pigeon pea infected with sterility mosaic virus by Narayanaswamy and Ramakrishnan (1965b) and ‘Etrog’ citron plants infected with exocortis virus by Kapur et al., (1974).

However, there are reports which show decrease in catalase activity in plants infected with different viruses. These include chilli infected with potato virus Y (Jeyarajan and Ramakrishnan, 1968), cucumber mosaic virus (Joshi and Dubey, 1976), sugarcane infected with sugarcane mosaic virus (Bhargava et al., 1970), soybean plant infected with soybean mosaic virus (Suteri, 1974), radish plant infected with radish mosaic virus (Upadhayaya, 1978), sun hemp plant infected with common bean mosaic virus (Singh and Singh, 1978), Luffa aegyptiaca Mill and L. acutangula Roxb. Infected with watermelon mosaic and squash mosaic viruses (Kulshreshtra, 1980), pumpkin plant infected with watermelon mosaic virus (Singh, 1983) and Cucurbita maxima infected with watermelon mosaic virus (Shukla, 1985). Tripathi (1990) reported that catalase activity is decreased in Cucurbita pepo L. infected with BGMV.
Polyphenoxidase Activity:

Hampton and Fulton (1961) reported inactivation of prune dwarf and cherry necrotic ring spot virus in tissue extracts probably due to oxidized polyphenols by polyphenoxidase activity. Vankammon and Brouwer (1964) observed quantitative increase in polyphenoloxidase activity in inoculated as well as uninoculated parts of TMV infected tobacco plants. John and Weintraub (1967) found increased polyphenoloxidase activity in TMV infected Nicotiana glutinosa, the activity increased with the development of necrotic local lesions. Barbara and Wood (1972) found a rise in PPO activity in CMV infected cotyledons of a susceptible variety of cucumber at about the time of second infectivity peak. Kato and Misama (1972) reported that PPO activity of tobacco tissues infected with CMV decreased during first two hours and subsequently increased gradually.

However, Vagetti et al., (1975) observed no stimulation of PPO activity during development of infection of pinto bean leaves with alfalfa mosaic virus and found that enzyme is not involved in systemic acquired resistance. Kulshreshtha (1980) observed increased PPO activity in Luffa aegyptiaca Mill and L. acutangula Roxb. Infected with watermelon and squash mosaic viruses, respectively, Shukla (1985) observed that virus infection increased the polyphenoloxidase
activity in comparison to their healthy counterparts. Tripathi (1990) reported increased polyphenoloxidase activity in comparison to their healthy *Cucurbita pepo* L. infected with bottle gourd mosaic virus (BGMV).

**Nitrate Reductase Activity:**

Records available on the nitrate reductase activity of virus infected plants appear to be scanty. Increased activity of the enzyme was noted in pigeon pea sterility mosaic virus infected pigeon pea (Narayanaswamy and Ramakrishnan, 1966b). A higher level of nitrate reductase activity in leaves of cowpea mosaic virus infected cowpea was noted by Khatri and Chenulu (1973). The nitrate reductase activity was less marked in virus infected resistant varieties of cowpea than the susceptible ones. Joshi and Prakash (1977) reported increased nitrate reductase activity in maize leaf infected with strain A and F of sugarcane mosaic virus. Shukla (1978) observed increased nitrate reductase activity in *Sorghum* leaf infected with sorghum strain of sugarcane mosaic virus (SCMV). Singh and Singh (1982) reported increased nitrate reductase activity in cowpea plant infected with cowpea mosaic virus. Singh (1983) found that pumpkin plant infected with watermelon mosaic virus infection, nitrate reductase had increased activity in infected leaves, stems and roots.
Singh and Singh (1978) reported decreased nitrate reductase activity in hyacinth bean leaves infected with yellow mosaic virus. Shukla (1985) reported that the nitrate reductase activity in both healthy and infected samples (leaf, stem and root) increased with the age of the plant. The virus infection increased the nitrate reductase activity in comparison to healthy ones. Tripathi (1990) observed that the nitrate reductase activity in both healthy and infected samples (leaf, stem and root) increased with the age of the plant C. pepo L.

**Carbohydrate Content:**

Studies on carbohydrate contents of virus affected plants revealed that some viruses may alter both the rate of synthesis and translocation of carbohydrate while other have little affect.

Dunlap (1930) categorized the viruses into two groups on the basis of their effect on carbohydrate metabolism: (a) The mosaic type causing reduction in carbohydrates and (b) The yellows type causing accumulation of carbohydrates.

However, the scientific studies on carbohydrate metabolism were started as early as in 1913, when Bunzell reported reduction in sugar content of leaves of sugarbeet infected with curly top virus. Since then several workers have reported decreased carbohydrate content in various plants and their specific parts infected with different viruses. These reports include blighted spinach plants (True
and Hawkins, 1918), mosaic infected tomato leaves (Brewer *et al.*, 1926), tobacco infected with tobacco mosaic virus (Cordingley *et al.*, 1934), sugars and starch in leaves of sugarbeet plants infected with yellows virus (Watson and Watson, 1951), reducing sugars in barley leaves infected with barley yellow mosaic virus (Orlob and Arny, 1961), reducing sugar in pheon pea affected with sterility disease (Narayanaswamy and Ramakrishnan, 1965; Nambiar and Ramakrishnan, 1969a, b, c), soluble carbohydrate and starch in barley leaves inoculated with barley yellow dwarf virus (Jensen, 1969), reducing sugars in leaves, stem and roots of sugarcane plants infected with sugarcane mosaic virus (Srivastava 1971), total sugars in “Etrog citron” plant infected with three isolates of exocaortis virus (Kapur *et al.*, 1974), starch and soluble carbohydrate in bottle gourd plants infected with bottle gourd mosaic virus (Dubey, 1977), sun hemp infected with common bean mosaic virus (Singh and Singh, 1978), been (*Dolichos lablab* L.) infected with yellow bean mosaic virus (Kabi *et al.*, 1979), cucumber leaves infected with cucumber mosaic virus (Sindelar *et al.*, 1980) and radish infected with radish mosaic virus (Upadhyaya, 1981), *Cucurbita maxima* infected with watermelon mosaic virus (Shukla, 1985).

Other reports showed an increase in total carbohydrate content and include potato plants infected with leaf, roll virus
(Campbell, 1925), mosaic infected sugarcane (Asuncion, 1925), reducing sugars, sucrose and starch in yellows affected leaves infected with brinjal mosaic virus (Naqvi et al., 1978).

Partially variable and different observations were recorded by few workers as Malhotra (1931) reported decrease in non-reducing sugar, starch and hemicelluloses in mosaic affected leaves whereas no change was found in the level of reducing sugar. Similar results were obtained by Khatri and Chenulu (1969) with cowpea plant infected with cowpea mosaic virus. Jensen (1969) studying the metabolism of barley leaves infected with barley yellow dwarf virus found an increase in carbohydrate and starch content upto 19th day of infection. After this starch continued to accumulate, but the carbohydrate content started to decrease.

Tripathi (1990) observed decreased content of the reducing sugar in comparison to their healthy counterparts, non-reducing sugar content in both healthy and infected samples increased with age of the plant, whereas the starch content decreased in comparison to their healthy counterparts in C. pepo L. infected with BGMV. Sharma et al., (1990) observed increase in carbohydrate content in plants infected by CGMMV. Patel and Patel (1995) also observed increase in total sugar content in bidi tobacco on TMV infection. Singh (1996)
carbohydrate content is decreased in *S. vulgare* infected with sugarcane mosaic virus.

**Nitrogen Content:**

An increase in the total nitrogen content was observed in the virus affected plants probably due to virus multiplication and synthesis of abnormal protein of the virus in addition to plant protein which collectively results for the increase in the content. However, some workers have reported decrease and a few others found no change in total nitrogen content of infected plants with little and ineffective scientific reasons.

Doby (1912) reported increase in total nitrogen content in potato leaves infected with leaf roll virus. Since then several workers have reported increase of nitrogen content in various infected with different viruses. These reports include diseased tobacco, tomato, buck weed, cucumber and raspberry plants infected with yellows disease (Dunlap, 1930), tobacco mosaic virus (Cordingley *et al.*, 1934; Stanley, 1937; Dolittle, 1942; Harman *et al.*, 1970), nodules of soybean plants infected with soybean mosaic virus (Tu *et al.*, 1970), tomato leaves affected with potato spindle tuber virus (Kapur and Wathers, 1971), chilli plants infected with potato virus *y* (Jeyarajan and Ramakrishnan, 1972), field bean infected with Dolichos enation mosaic virus in sand culture experiment (Rajagopalan and Raju,
1972), cowpea infected with cowpea mosaic virus, the increase being less in resistant than susceptible varieties (Khatri and Chenulu, 1973) different parts of chilli plants infected with cucumber mosaic virus (Joshi and Dubey, 1974), parts of capegoose berry plants infected with cucumber mosaic virus (Joshi and Gupta, 1975), soybean affected with alfalfa mosaic virus (Mali et al., 1977), bottle gourd plants infected with bottle gourd mosaic virus (Dubey, 1977), different parts of cowpea plants affected with Southern bean mosaic virus (Singh et al., 1978), cowpea plants infected with cowpea tobacco mosaic virus (Mali et al., 1980). Luffia aegyptiaca Mill and L. acutangula Roxb. Infected with watermelon mosaic and squash virus (Kulshreshtha, 1980) and cowpeas fruits affected with cowpea mosaic virus (Singh and Singh, 1981) Cucurbita maxima affected with watermelon mosaic virus (Shukla, 1985).

Decrease in total nitrogen content of mulberry plants infected with leaf roll was recorded by Suzuki (1902) and spinach leaves infected with blight and mosaic (Jodidi et al., 1920), tomato leaves affected with curly top (Wann and Blood, 1933), chilli plants infected with potato virus y (Jeyarajan and Ramakrishnan, 1961), banana plants infected with bunchy top (Jose et al., 1973), hollyhock leaves infected with hollyhock yellow mosaic virus (Singh and Verma, 1974), and citron plants affected with three different isolates of exocortis
virus (Kapur et al., 1974), chilli plants infected with tobacco leaf curl virus (Singh and Singh, 1976) and groundnut leaves infected with bud necrosis virus (Ramapandu and Raychaudhuri, 1979).

However, Bunzell (1913) did not notice any significant change in nitrogen level in beet plants infected with curly top virus. Gordon (1966) also recorded ineffective difference in barley leaves affected with barley stripe mosaic virus.

Singh and Singh (1986) observed the BYMV infection increase the nitrogenous fractions except ammonical nitrogen in comparison to healthy plants. Tewari et al., (1988) observed the levels of total nitrogen in higher in *Cucurbita maxima* in comparison to their healthy plants infected with watermelon mosaic virus. Tripathi (1990) observed the total nitrogen content increased in comparison to healthy counterparts in *C. pepo* L. Patel and Patel (1995) observed infection of TMV, total nitrogen is reduced. Tewari and Dixit (2001) observed the strains of Benincasa mosaic virus (BMV) increase the nitrogenous fractions except ammonical nitrogen in comparison to healthy plants.

**Protein Content:**

Protein form an essential structural and fundamental component of the cell, with virus multiplication in plants, abnormal proteins are synthesized in addition to normal plant proteins,
resulting in overall increase of total nitrogen. But virus protein may increase in some cases at the cost of normal protein when total nitrogen may not increase or some time it may even decrease depending upon a number of factors. About one-third of nitrogen content of a tobacco plant infected with tobacco mosaic virus may eventually be in the form of virus (Bawden and Pirie, 1946). The proportion may go up to 60 percent in plants receiving large amount of phosphorus and little nitrogen (Holden and Tracy, 1948). Accompanying the protection of this large amount of virus there is no corresponding increase in total nitrogen.

Stanley (1937) observed that the extracts of Turkish tobacco plants diseased with tobacco mosaic and Aucuba mosaic viruses were found to contain two or three times more protein nitrogen than the extracts of healthy ones. Later Martin et al., (1938) observed very little change of protein content in mosaic infected tobacco plants in comparison to healthy ones, irrespective of the severity of the disease, Hills and Mckinney (1942) studied the effect of mosaic virus infection on protein content of susceptible and resistant strains of tobacco. They that protein contents increase or decrease with increasing or decreasing nitrogen content in susceptible and resistant strains. Takahashi and Ishii (1952) observed that tobacco mosaic virus infected Turkish tobacco and tomato plants contain, in addition to
virus varying amount of abnormal protein which is serologically related to tobacco mosaic virus.

Commoner et al., (1953) observed that virus synthesis was associated with net increase in protein content in tobacco plants infected with tobacco mosaic virus. John (1963b) observed that protein nitrogen was higher in tobacco plants infected with strains of tobacco virus as compared to healthy ones.

Suteri (1974) observed higher protein content in soybean seeds from infected soybean plants. Gupta (1975) reported that soybean infected with soybean mosaic virus had more protein content in the nodules of diseased plant. Suteri and Srivastava (1975) reported higher protein content in yellow mosaic virus infected soybean seeds of varieties Bragg, clark-63, Lee and Local-2 at maturity. Variety Local-2 showed higher ratio than the Bragg. A higher amount of protein was noticed in pigeon pea infected with arhar (Pigeon pea) mosaic virus (Singh and Mall, 1976), in groundnut infected with groundnut mosaic virus (Srivastava, 1976). Singh and Singh (1978) reported increased protein content of sun hemp leaves infected with common bean mosaic virus. Shukla (1985) observed an increase in protein content in C. maxima (leaf, stem and root) affected with watermelon mosaic virus.
A decreasing trend in protein content was noticed by Stanley (1937). He highlighted that tobacco plants infected with masked tobacco mosaic, green or yellow tobacco mosaic, severe etch, tobacco ring spot and latent mosaic viruses decreased the protein content of tobacco plant, Takahashi (1947) observed that tobacco mosaic virus synthesis in detached leaves took place in detached leaves took place in the dark under condition known to cause hydrolysis of normal protein showing thereby that tobacco mosaic virus synthesis was from normal proteins. Krayer (1965) noticed a reduction of protein content in green organs of mosaic infected broad been plants. Shukla (1978) reported reduced protein content in the seeds of *Sorghum* infected with sugarcane mosaic virus than healthy ones.

Tripathi (1990) observed the increase in total protein content in comparison to their healthy counterparts in *C. pepo* L. infected with BGMV. Patel and Patel (1995) observed infection of TMV, decreases protein content in infected plant. Tewari and Dixit (2001) observed that Benincasa mosaic virus (BMV), increases the protein and different free amino acid contents in comparison to healthy *C. pepo* L. plants.

**Mineral Content:**

Singh (1983) observed that water melon mosaic virus (WMV) increases the total and organic phosphorus level and decreases the
inorganic phosphorus level in infected plants in comparison to healthy plants of pumpkin, *Cucurbita maxima* Duch. Tewari and Dixit (2000) reported that Benincasa mosaic virus (BMV) increases the total and organic phosphorus and decreases the inorganic phosphorus level in *Cucurbita pepo* L. in comparison to their healthy plants.

**Part-II**

**Control or Eco-friendly Management Measures:**

The management of plant virus diseases may seem like simply a popular philosophy for the control of most important virus diseases as the use of modern pesticides for control of the other plant pathogens. Various factors are helpful in devising control measures for aphids and insects transmitted viruses. Assessment of aphid population present on crops or alate incoming migrants may give an indication of disease incidence. Monitoring the time of migration of aphids and fluctuations in population in relation to weather factors may be helpful in forecasting disease and timing of schedules for protection of crops. The work done in devising methods for assessing the size of aphid population, monitoring of aphid vectors and control of aphid population by chemical and non-chemical methods is being reviewed here –
Vector Population:

The incidence of vector population may be due to various factors. It is of critical concern in disease incidence and an index can be taken as the number of vectors (aphids) and rate of reproduction within a field to predict disease. The rate of reproduction and the generation time of aphid may, in turn, be influenced by temperature. Thus the determination of the physiological nymphal development time and mean generation time in day degrees may give an indication of the size of vector population (Blackman, 1975). The number of aphids present on plants has been used as an index for prediction of diseases (Broadbent, 1950; Byrne and Bishop, 1979). Virus disease incidence however, may not always be correlated with vector population present on the plants parse, and the spread has been found to be better correlated with the number of alate caught on sticky traps (Carter, 1973). The number of aphids carrying non-persistence viruses such as beet yellows and potato virus Y was not found to be correlated with the disease incidence as very few aphids can spread the disease in short time and the vectors of non-persistent viruses may be non-colonizers.

Use of insecticides and Oil Sprays:

The control of air-borne insect vectors with insecticides has been more effective against persistently than non-persistently
transmitted viruses. This is because with the former, aphid vectors require several hours to acquire and transmit the virus. In these situations, systemic insecticides can provide effective control (Hull and Heathcote, 1967), especially when applied in granular form at planting so that the active ingredient is slowly released to maximize the period which the plant is protected. The organophosphorus insecticides disulfon and phorate have been particularly useful for the control of the carrot aphid *Cavariella aegopodii*, the vector of the carrot motley dwarf virus (Dunn, 1963; Lindley, 1963; Dunn and Kempton, 1967) where the young crop is protected from aphid colonization at emergence thereby showing down motley dwarf epidemics when the carrot seedlings are most susceptible to infection.

Unfortunately, the continued use of insecticides has resulted in the development of resistant aphid (Devonshire and Moores, 1982), thus demonstrating their shortcoming together with the fact that they are inefficient or possibly useless in preventing transmission form incoming vectors, a problem particularly acute with non-persistent viruses such as CMV, or PVY (Lobenstein and Raccah, 1980). More recently, new synthetic pyrethroids have been introduced. These are fact acting have low mammalian toxicity and initially appear to counteract the increasing resistant of the target insect as occurred with the other older insecticides. They remain to be fully assessed but

Following the original discovery that oil prevented aphid transmission of PVY (Broadley et al., 1966) and many research workers have since conformal its effectiveness, if applied as field spray, in decreasing the spread of CMV and different viruses in different crops (Kulp, 1968; Lobenstein et al., 1966, 1970; Russel, 1970; Hein, 1971, 1972, Singh et al., 1973; Peters and Lebink, 1973; Butter and Rataul, 1973; Zitter and Everett, 1979; Singh, 1981; Simons, 1982; Basky, 1982; Srivastava et al., 2006). The effectiveness of the treatments depends on several parameters including the type of mineral oil used, the choice of emulsifiers, the type of spray nozzle and the spray pressure.

**Use of traps for monitoring and controlling vectors:**

Several types of traps have been used for catching air borne vectors. Aphids and leaf-hoppers mainly are attracted towards yellow color so yellow traps are commonly used. Yellow sticky traps have been used by several workers to monitor vector and to reduce disease incidence.
Broadben (1950) found correlation between numbers of alate aphids caught on sticky traps and the spread of potato leaf roll. On the basis of average trap catch data, the health of potato crop of following years could be predicted. Conditri and Tuttle (1963) used yellow sticky boards to monitor migration and spread of aphids and consequent spread of various diseases. The incidence of lettuce mosaic, beet yellows, beet western yellows, cucumber mosaic and watermelon mosaic increased with increase in the number of aphids as seen trap catches in spring. Yellow sticky polythene sheets were used to monitor aphids and to reduce the spread of PVY on peppers (Cohen and Marco, 1973), potato leaf roll, PVY, and alfalfa mosaic virus (Zimmerman, 1979), Cucumber mosaic virus (Cohen and Maree, 1973; Raychaudhuri and Varma, 1978).

Using different traps, Basky (1981) found that aphid population was maximum in early June and this was correlated to CMV and watermelon mosaic virus diseases which appeared in late July or early August. Yellow pan containing water mixed with soap or insecticides have also been used to trap aphids. In Hungry, Basky (1983, 1985) while monitoring aphid population found it to be greater in June and these aphids were vectors of CMV, PVY and tomato spermy viruses. The viruliferous aphids appeared one month after peak infestation. The pan traps were also found effective for
monitoring aphid types (Bokx and Piron, 1985) but to catch live aphids for infectivity tests horizontally suspended conical net traps were found effective. The live aphids caught in net traps were found infective for PVY. Rabase et al., (1982) while monitoring ablate aphids in carrot fields have reported that yellow water traps 10-15 cm. in diameter and placed 2-8 m. distance were most effective. The number of traps and the distance between them could be worked out by coefficient of variation studies which should between 10% an 34%. In comparison of four types of traps for aphid monitoring, the best was found to be the large suction trap in comparison to yellow water trap, conical net and small mobile suction trap (Bokx and Pirons, 1985). Trumble et al., (1982) while comparing yellow sticky traps and water traps for monitoring aphids, Myzus persicae, Lygaphis erysimi and Brevicoryne brassicae found cylindrical yellow sticky traps were more effective than water traps. The air borne population was found to be uniformly distributed over unsprayed and sprayed crops of broccoli. Singh et al., (1984) and Sharma et al., (1991) used yellow water traps to monitor alate aphid population in potato fields and in bell pepper fields respectively in Himachal Pradesh in India. Aphids have also been captured on green tiles used to sticky traps (Raach et al., 1988). Prasad and Phadke (1983) at IARI, New Delhi, have monitored aphids on yellow sarson (Brassica campestris) crop using yellow sticky
cylindrical jars (15 × 10 cm.). The aphids *Lysaphis erysimi* appeared in first week of March. The trap catches could be correlated with maximum mean and minimum temperature. The yellow sticky traps have also been used to monitor *Parabemisia myricae* in citrus orchard (Meyerdirk and Morens, 1984), to monitor as well as to suppress the population of *Trialeurodes vaporariorum* in green house (Webb et al., 1985; Bhiemal and Hansdorf, 1986; Gillespie and Don Quiring, 1987) and to monitor beet leaf-hopper, *Circulifer tenellus*, vector of *Spiroplasma citri* in fields (Meyerdirk and Oldfield, 1985). Vani et al. (1989) also at IARI, New Delhi, used cylindrical yellow sticky traps to monitor aphid population (*Myzus persicae* and *Aphis craccivora*) carrying cucumber green mottle mosaic virus and watermelon mosaic virus. Shukla et al., (2007) have also been used reflective polythene mulches in cucumber against watermelon mosaic virus in eastern Uttar Pradesh. The yellow cylindrical sticky traps are thus, efficient tools for monitoring aphid vector population and to detect their first invasion and dispersal. Most often the vector incidence has been found to be correlated with disease incidence.

**Use of Plant Products:**

Many plants contain toxic compounds and some are selectively poisonous to insects and have proved valuable as insecticides. Control of viruses has also been shown by activating the natural
defiance mechanisms against viral infection by certain plant extracts. The point of value is that these compounds do not appear to induce resistance in the insect pests. Plants possessing insecticidal properties are numerous. Ahmed et al., (1983, 1984) have given a comprehensive lists of names of plants which have been found toxic to insects, which are known as virus vectors. Approximately 2000 plant species are known to possess pest- control properties, and their mode of action varies from outright kill to modifications of the pest behaviour. The plant parts mostly used for pest control are whole plant, leaves or fruits used as extracts. The oils from several plants obtained by distillation from leaves or by extraction from fruits/seed have also been tested for their insecticidal effects and also for their inhibitory action on viruses.

Rao et al., (1987) have reported essential oils from several plants, Ageratum conyzoides, Callistemon lanceolatus, Carum cappicum, Ocimum sanctum, Peperomis pellucida to be inhibitory to cowpea mosaic, mungbean mosaic, bean common mosaic and southern bean mosaic virus when mixed with the viruses. Ocimum oil gave best results. Lei et al., (1984) reported that Brassica campestris seed oil inhibited mechanical inoculation of TMV and CMV. Shukla et al., (1989) found that noils from Foeniculum vulgare and Pimpinella asium when mixed with PVX, TMV, TRSV and nepovirus, etc. at 3000 ppm inhibited
lesions development by the viruses. As regards, the effect of oils on virus transmission by vectors very few reports are available. Boss et al., (1983) found that oil from *Anemocalymma allacea* prevented acquisition of virus by *Aphis gossypii* form infected plants. In the experiments, with several oils against rice tungro virus transmitted by *Nephotettix virescens*, Srinivasulu and Jeyarajan (1988) reported that preinoculation sprays with cotton seed oil, neem, *Pongamia glabra*, mustard and *Ceiba pentandra* oil reduced rice tungro virus transmission and survival of the vector. The plant extract has been found also to inhibit viruses (Verma, 1974; Tripathi and Tripathi, 1982; Chawdhury and Saha, 1985; Zaidi et al., 1988). Ketkar (1976) has reviewed the aphicidal properties and feeding inhibition of neem seed extracts against *Aphis gossypii* and *Brevicoryne brassicae*. Siddig (1981) reported that aqueous neem leaf extracts and seed extracts reduced feeding by *Aphis gossypii* on okra in Sudan. Aqueous neem seed extracts also reduced *Aphis gossypii* infestation in potato fields (Jacob and Sharma, 1983). Raychaudhury (1984) reported toxic effect of neem seed kernel extracts and neem oil emulsion on *Aphis craccivora*. The different parts of neem plant have been analyzed and reported (Neem in Agriculture, 1983). The chemical components in neem leaf, bark, flowers, kernel, oil and neem cake have been found to be variable. Many Plant leaf extracts viz. *Capsicum annuum*, *Datura Stramonium*, *Boerhaavia diffusa*, *
Clerodendrum aculeatum, Chenopodium ambrisoides, Hordeum vulgare, Mirabilis jalapa, Bougainvillea spectabilis, Datura metel, Zinzibar officinalis, Argemone mexicana, Solanum melongena, Allium sativa, Phytolacca dodecandra, Parthenium hysterophorus, Sorghum vulgare, Prosopis chilensis, were strong inhibitors when co-inoculated with different viruses (Paliwal and Nariani, 1965; Verma and Mukherjee, 1975; Joshi and Prakash, 1978; Patel and Patel, 1979; Verma and Awasthi, 1980; Verma and Dwivedi, 1983; Verma et al., 1985; Leah et al., 1991, Kataoka et al., Baranwal and Ahmad, 1997; Pun et al., 2005; Ansari and Tewari, 2005).

Breeding for Resistance:

The importance of any crop virus disease depends on the genotype being grown. The seriousness of the disease and the course of epidemics are a reflection of the interaction between the particular cultivars, the environment and the strain of the virus causing the infection. The potential for influencing virus disease by altering the crop genotypes is great and possibly has under utilized. Most vegetable crops species have much variability and therefore, the potential to be poor hosts of viruses and of their vectors. Breeding for resistance to virus infection can be done at an empirical level with little knowledge of the genetic basis, however, a more responsible exploitation of genetic resources is facilitated if the genetic mechanism is known, thereby facilitating the production of more
durable resistance to the genetic system of the virus (Tomlinson, 1987).

Progress in breeding for resistance to the vegetable viruses have been recorded in several vegetable crops (Walkar, 1953; Ryder, 1970; Hall, 1980; Fraser and Gerwitz, 1986; Ram et al., 1999; Verma et al., 2005).

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