Virus and Virus-like Diseases of Plants in Ethiopia

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Introduction

Viruses are the second most important plant disease agents, next to fungi, causing severe crop losses worldwide (Matthews 1991). The occurrence of plant virus diseases in Ethiopia was first reported by Stewart & Dagnachew (1967) who listed a number of virus-like symptoms on different plants. A systematic research on plant viruses was started in 1977 after the establishment of the then Scientific Phytopathological Laboratory at Ambo (now Plant Protection Research Center). Since then, various types of plant viruses and virus diseases have been identified and some of them were investigated in a good detail by researchers from within and outside Ethiopia. Most of the results were documented in various national and international publications. However, a comprehensive review to bring this scattered information together has not been available. In this paper therefore, information on plant virus and virus-like diseases so far reported in Ethiopia is presented with description of the symptoms in the major hosts and means of natural spread for economically important viruses as well as their geographical distribution where known.

Cereals

Maize and Sorghum

In Ethiopia, four viruses are reported to infect maize; maize streak geminivirus (MSV), sugarcane mosaic potyvirus (SCMV), maize dwarf mosaic potyvirus (MDMV) and maize mottle chlorotic stunt virus (MMCSV) (Delassus 1973, Alemu et al. 1997). MSV that is endemic to Africa is one of the major maize diseases in low altituds. Although, yield loss assessment due to MSV has not been done in Ethiopia, losses of upto 100% has been reported in Nigeria depending on the time of infection (Soto & Buddenhagen 1978).

Maize streak disease was first recorded in Ethiopia by Delassus (1973), but its economic importance was first reported by Tekle Mariam (1986) in Abobo (Gambela), western Ethiopia, who reported a high incidence. Since then, the disease has continued to spread to most of the maize growing regions including mid-altitude zones such as Ambo and Ginchi in West Shewa (Tewabech 1990, Alemu et al. 1997). Although its current economic importance appears to be in low altitude areas, the disease was observed in almost all maize growing areas of western, southern and northern Ethiopia at low incidence. Most of the improved maize varieties released for mid altitude areas of the country are susceptible to MSV (Benti 1987).

Symptoms of MSV in maize consist of prominent white chlorotic broken or almost continuous streaking developing over and along the leaf laminae. The virus is transmitted by leafhoppers of genus *Cicadulina*, of which, *C. mbila* is implicated to be the most important vector in Ethiopia (Mesfin et al. 1991). Disease incidence is dependent on leafhopper population which in turn is influenced by rainfall, temperature and the availability of alternate hosts (Rose 1978). Many grasses act as overseasoning host for the virus and/or its vector thus playing important role in the epidemiology of the disease. MSV was observed or detected on naturally infected grasses of genera *Hypparhenia, Pennisetum, Rottboella, Setaria, Panicum, Eluesine, Sorghum* in the country (Mesfin *et al.* 1991, Alemu *et al.* 1997). Some of

these grasses may play a role in the epidemiology of MSV but transmission experiments should be done before arriving to final conclusion since MSV isolates from the grasses may represent different strain(s) from that of maize. Maize mottle chlorotic stunt virus (MMCSV), a virus also transmitted by *Cicadulina* leafhoppers is recorded recently from maize in Ethiopia (Alemu et al. 1997) but there is no information on its distribution and economic importance.

A mosaic disease of maize caused by sugarcane mosaic potyvirus (SCMV) is the second widespread virus disease with incidence as high as 20 % in some areas (Alemu et al. 1997). Main symptoms include irregular chlorosis, mottling and striping. The virus is transmitted by several aphid species including *Rhopalosiphum maidis, R. padi, Myzus persicae* and *Aphis craccivora* (Brunt *et al.* 1996) which are also present in Ethiopia (Crow & Kemal 1983). Maize dwarf mosaic potyvirus (MDMV) which also causes mosaic is less frequently encountered in Ethiopia (Alemu *et al.* 1997). It is transmitted by identical aphid species and causes similar symptoms to SCMV.

In sorghum (*Sorghum vulgare*), Bos (1974) visually recorded a high incidence of stripe mosaic and severe plant stunting in a trial field at Abela and Soddo in North Omo zone. Similarly, a mosaic symptom suspected to be due to virus was visually observed by Mengistu (1982) in Nazreth area but the virus was not accurately identified. The disease however has limited distribution and minor economic importance. It is not yet clear whether mosaic diseases of maize and sorghum in Ethiopia are caused by an identical or different viruses or their strains.

Barley and Wheat

Yellow dwarf disease caused by barley yellow dwarf luteovirus (BYDV) is the most prevalent virus disease of barley and wheat in Ethiopia. The disease was first reported in barley by Stewart & Dagnachew (1967). BYDV is found in all regions where barley and wheat are grown. It has thus been reported from Shewa, Arsi, Sidamo, Wellega, Bale, Gojam, Gonder and Wello zones. Studies also showed that all the five serotypes of BYDV infect both barley and wheat in Ethiopia (Agranovsky et al. 1985, Abdulrazak et al. 1989, Dereje et al. 1992, Berhanu 1998). Disease symptoms include leaf yellowing and reddening, stunting and rosetting in both wheat and barley. Annual and perennial grass weeds and volunteer cereals play an important role in the epidemiology of yellow dwarf in barley and wheat (Irwin & Thresh 1990). Of more than 20 species of aphids known to transmit BYDV, the most important vectors such as *Rhophalosihum maidis, R. padi, Schizaphis graminum* are known to occur in Ethiopia (Crow & Kemal 1983). Little information however exists on the principal aphid species acting as natural vector(s) and grass hosts playing role in disease epidemiology. Most of the BYDV resistant factors in the world barley collections had been obtained from the Ethiopian barley land races, and the responsible gene called Yd2 is transferred and effectively utilized (Qualset 1975). This indicates that there is a good genetic potential in the Ethiopian barley land races for yellow dwarf management through host resistance.

Stewart & Dagnachew (1967) recorded symptoms of barley stripe mosaic hordeivirus (BSMV) in barley, a widely spread virus in cereals naturally transmitted only through seed. This virus has however not been encountered on surveys done since then.

Legumes

Highland Pulses

A recent survey showed that faba bean necrotic yellows nanovirus (FBNYV) and luteoviruses including bean leaf roll luteovirus (BLRV) and beet western yellows luteovirus (BWYV) are the most widespread viruses of faba bean (*Vicia faba*) in Ethiopia (Adane & Alemu 1998). For FBNYV, disease incidence as high as 25, 80 and 100% was recorded in Asasa (Arsi), Ankober (North Shewa) and Dessie Zuria (South Wello), respectively. In most other locations, the incidence varied from low to none. FBNYV symptoms in faba bean include a thick and brittle leaf showing chlorosis, leaf rolling and necrosis and stunting of infected plants. FBNYV naturally infects faba bean, field pea, chickpea and lentil, mainly in the Middle East and North African countries (Katul et al. 1993). It is transmitted by two aphids which are also common on legumes in Ethiopia, *Acyrthosiphon pisum* and *Aphis craccivora* (Katul

et al. 1993). The FBNYV isolate from Ethiopia is serologically distinct from those in other countries and is thus grouped as a distinct serotype (Franz *et al.* 1996). Therefore, it is interesting to study if the Ethiopian isolate is also a distinct pathotype differing in important biological characteristics such as symptom severity and type of aphid vectors as well as its transmission efficiency in specific vectors. With the hope of finding source of resistance to FBNYV, several thousands of faba bean genotypes were screened in Ethiopia, Egypt and Syria by artificial aphid inoculation under field condition but reliable source of resistance is not yet obtained.

FBNYV and luteoviruses show similar symptoms and are also transmitted by similar groups of aphids. They can also occur in mixed infection in a field. Other viruses recorded in faba bean but with apparently minor economic importance are chickpea chlorotic dwarf geminivirus, bean yellow mosaic potyvirus, pea seed-borne mosaic potyvirus, broad bean stain comovirus and broad bean wilt fabavirus (Makkouk *et al.* 1993, Adane & Albrechtsen 1998, Adane & Alemu 1998).

Stunt disease is considered to be the second most important disease of chickpea (*Cicer arientinum*) in the country next to wilt/root rot (Seid *et al.* 1990). The characteristic symptom is stunting, yellowing or browning, proliferation and phloem browning particularly in the collar region. The main causal agent of chickpea stunt in Ethiopia is beet western yellows luteovirus (BWYV) (Tadesse *et al.* 1999). Stunt appears to occur wherever chickpea is grown, but higher incidence was recorded in warmer areas that favour aphid population build-up. As high as 41.3% BWYV incidence was recorded (Tadesse *et al.* 1999). The virus is transmitted by several aphid vectors including Aphis craccivora and Myzus persicae which also occur in Ethiopia (Crow & Kemal 1983). Chickpea genotypes provided by International Center for Agricultural Research in Dry Areas (ICARDA) were screened in the country under natural condition and a high level of stunt resistance was obtained in eight lines (Mengistu & Negusse 1994). Other viruses, encountered rarely in chickpea are FBNYV and broad bean wilt fabavirus (Tadesse *et al.* 1999) and their economic importance appears to be minor.

In lentil, pea seed-borne mosaic potyvirus (PSbMV) is by far the most commonly encountered followed by luteoviruses (BWYV and soybean dwarf luteovirus) and FBNYV. The highest incidence recorded for PSbMV was 58.5% (Tadesse *et al.* 1999). The results showed that there is a great variation among lentil fields with respect to PSbMV prevalence. This is probably because PSbMV is highly seed-borne and farmers use seeds with different level of infection which in turn is further spread by aphids like Acyrthosiphon pisum which heavily colonizes lentil in the country. The use of certified virus-free seeds can help to avoid such problem. Broad bean stain comovirus, bean yellow mosaic potyvirus and cucumber mosaic cucumovirus were also recorded in lentil but rarely (Tadesse *et al.* 1999).

Lowland Pulses

Mosaic in haricot bean (*Phaseolus vulgaris*) caused by bean common mosaic potyvirus (BCMV) is the most common virus disease (Bos 1974, Agranovsky 1985a). BCMV is transmitted in nature by seed and by aphids. However, disease incidence was usually low and thus it has never been a major problem in bean production except in some experimental fields in research stations.

An extensive survey conducted in Ethiopia by Spence & Walkey (1993) revealed that serotype A strains of BCMV, prevalent in many countries causing systemic necrosis called black root in cultivars with dominant I-genes, were absent in Ethiopia. Only serotype B strains (mosaic inducing strains) were present. Black root symptoms are, however, recently observed in experimental sites at Ambo and Awassa research centers and necrotic strains were isolated from plants in these fields (Alemu *et al.* 1998), possibly being imported with seed from other countries. It is therefore necessary to strengthen the quarantine system to check bean seeds being imported from other countries to prevent the introduction and spread of necrotic strains. These necrotic strains of BCMV have been reclassified as a new virus named bean common mosaic necrosis potyvirus (Vetten *et al.* 1992). Peanut mottle potyvirus (PMV) was also reported as causing mosaic disease in haricot bean near Lake Shalla (Spence & Walkey 1993).

In soybean (*Glycine max*), mosaic caused by soybean mosaic potyvirus (SbMV) has been observed wherever the crop is grown (Bos 1974, Agranovsky 1985a, Adane & Albrechtsen 1998). The virus is transmitted by seed and by aphids. The other viruses identified in lowland pulses are peanut mottle potyvirus in peanut and cowpea aphid-borne mosaic potyvirus in cowpea (Agranovsky 1985a). Spence & Walkey (1993) isolated cucumber mosaic cucumovirus in lima bean (*P. lunatus*) from Diri and peanut mottle potyvirus in *Cassia sophera* from Bonga and Jimma areas, all in western Ethiopia. A potyvirus named as *Cassia* severe mosaic potyvirus is isolated from *Cassia occidentalis* in Nazreth area (Walkey et al. 1994b). Mosaic and yellow spotting in mungbean (*Phaseolus radiatus*) and mosaic on lima bean (*Phaseolus lunatus)* were observed although the causal viruses were not determined (Bos 1974, Marchoux 1976). Except for BCMV, all the viruses listed above from lowland pulses are identified only from few samples and there is no information on their incidence and distribution. Detailed survey should therefore be conducted to estimate their economic importance.

Vegetable Crops

Pepper

Virus diseases are known to be major constraints in pepper (*Capsicum* spp) production in Ethiopia for a long time (Marchoux 1970, Bos 1974, Agranovsky 1985b, 1993). Virus infection has been recorded in almost all pepper growing.areas of the country with disease incidence and yield loss being estimated between 40 to 100% and 15 to 50%, respectively (Agranovsky 1993, Yaynu et al. 1999). Previous surveys showed that potato Y potyvirus (PVY), pepper veinal mottle potyvirus (PVMV), tobacco mosaic tobamovirus (TMV) and a new potyvirus with distinctive properties, tentatively named Ethiopian pepper mottle virus (EPMV) are the four widely distributed viruses (Agranovsky 1985b, 1993). Cucumber mosaic cucumovirus and alfalfa mosaic alfamoyirus are occasionally encountered in pepper (Qiuot 1976, Agranovsky 1993). Recent survey revealed that PVY and EPMV are not only the most predominant viruses but also occurred frequently in mixed infections resulting in severe disease symptoms (Yaynu *et al.* 1999). Management efforts should therefore be directed towards these two viruses. PVMV and tomato mosaic tobamovirus (ToMV) were detected in few samples and limited locations (Yaynu *et al.* 1999).

There is, however, a contradicting report on the importance of TMV from survey results done by the different authors. According to Agranovsky (1985b), TMV is a widespread virus in Ethiopia particularly being endemic to most areas in Wellega region. In contrast, Yaynu *et al.* (1999) reported that TMV is completely absent in Ethiopia and that only tomato mosaic tobamovirus (ToMV) is identified in some areas. The reason for this discrepancy is not clear but it is possible that in earlier surveys, ToMV was misidentified as TMV since these two tobamoviruses are difficult to differentiate only by serology and electron microscopy. It should also be mentioned that Yaynu *et al.* (1999) did not collect and test samples from most parts of Wellega region where TMV is earlier reported to be endemic and widely distributed (Agranovsky 1985b). Thus, more detailed survey is required to have a better understanding of the relative importance of pepper viruses in general and TMV in particular in some areas.

Most of pepper viruses in the country are naturally transmitted by aphids. Pillipjuk et al. (1986) indicated that *Myzus persicae* was found to be the most widespread and efficient vector in transmitting potyviruses, cucumber mosaic cucumovirus and alfalfa mosaic alfamovirus in Ethiopia. Source of resistance to PVY, EPMV and TMV was obtained in sweet pepper cultivars Yolo Wonder, Agronomico-8, and breeding line 91523 as well as several hot pepper lines (Agranovsky & Mitiku 1986) but the result is not yet utilized by breeders.

Potato

Virus diseases of potato (*Solanum tubersum*) occur wherever the crop is grown although they are particularly severe in warmer parts of the country (Bekele & Yaynu 1992). Potato being a vegetatively propagated crop, viruses accumulate in successive generations causing degeneration and subsequent yield reduction. Earlier surveys showed that potato leaf roll luteovirus (PLRV) and potato Y potyvirus (PVY) which are the most

important potato viruses worldwide, were commonly encountered only in research stations but not in farmers fields, whereas potato viruses X, M and S were the most common at all locations (Knjazev & Yaynu 1982, SPL 1986). In recent surveys however, it was shown that PLRV and PVY are becoming important at both research stations and farmers field (Bekele & Berga 1995). Serological test of some potato clones and cultivars at Holetta Agricultural Research Center revealed that in 1993, PVY is the most frequently detected (46%) followed by PLRV (39.3%) whereas PVX and PVS is less frequent with 15% and 5%, respectively (Bekele & Berga 1995). This suggests that released potato clones should be tested and cleaned from viruses prior to disseminating them to farmers. Attempts should, therefore, be made to introduce the use of tissue culture technique to get virus-free potato seeds. With the exception of PVX, which spreads naturally by contact of infected and healthy plants or contaminated implements, all the other viruses are transmitted by aphids of which green peach aphid (Myzus persicae) is the most efficient vector (Brunt *et al.* 1996).

Tomato and Tobacco

Early reports showed that tomato (*Lycopersicon esculentum*) is affected by mosaic disease caused by tomato mosaic tobamovirus (ToMV) in many parts of the country, with infestation varying from 15 to 100% and predicted yield loss estimate of up to 30% (Agranovsky & Anisimoff 1986). Recent survey, however, revealed that tomato mild mottle potyvirus (TMMV) is the most predominant virus in tomato fields inspected with the highest incidence being recorded in rift valley areas (Yaynu *et al.* 1999). Only a small fraction of the samples tested were infected with ToMV and PVY. The reason for the shift in the importance of ToMV from a major to minor during this period is not clear.

TMMV is a new virus recently described from tomato crops in Yemen (Walkey *et al.* 1994a) and thus the previous workers (Agranovsky & Anismoff 1986) did not have the chance to test the suspected tomato samples for TMMV. Its high incidence in tomato however suggests that the virus may have been infecting the crop in the country for long time without being detected. Future studies should concentrate on the yield loss TMMV causes on tomato and management options such as host resistance. Yaynu *et al.* (1999) also detected TMMV from two associated weeds, *Datura stramonium* and *Nicandra physalodes* that may act as alternate hosts for the virus. Another virus occasionally detected on tomato in earlier surveys is potato virus X (PVX). Virus isolates reacting with antisera against tomato aspermy virus and tomato spotted wilt virus were recorded in tomato (Agranovsky & Anisimoff 1986). These three viruses, however, were not reported in recent surveys (Yaynu *et al.* 1999). More repeated survey is need to determine the occurrence and relative importance of tomato viruses in the country.

In tobacco, Bos (1974) observed mosaic and leaf curling symptoms at Melka Werer which he presumed to be caused by tobacco mosaic tobamovirus and tobacco yellow leaf curl geminivirus, respectively. Marchoux (1976) reported the presence of tobacco mosaic tobamovirus and potato virus Y in tobacco at Bilate tobacco farm and Awassa, southern Ethiopia. He also observed plants showing yellow leaf curl symptoms typical of virus from these places. Tobacco mosaic tobamovirus, potato virus Y and cucumber mosaic cucumovirus were also identified from tobacco (Gordeichuk & Abdulrazak 1980). However, the studies on tobacco were discontinued and the current importance of these viruses is not well known.

Enset (*Enset ventricosum*) and Other Vegetable Crops

Enset affected by a virus disease causing either streak or deep yellow stripe symptom that at an advanced stage become necrotic where the whole leaf may shred apart, Bacilliform particles belonging to badnavirus group of plant viruses and which have similarity in serology and morphology to banana streak badnavirus (BSV) were isolated from the infected leaves (Mesfin *et al.* 1995). Whether the virus is identical to BSV, a host adapted strain of the same virus, or a completely different virus is yet to be known. The disease appears to be widely distributed but its impact on the yield of enset awaits further investigation.

Concerning other vegetables, yellow dwarf symptom on onion (*Allium cepa*) has been observed by Bos (1974) in Nazreth area.

Agranovsky (1985c) also identified onion yellow dwarf potyvirus from onion samples from Ambo area. In lettuce (*Lactuca sativa*), a mosaic disease caused by lettuce mosaic potyvirus is observed and detected in some areas (Bos 1974, Adane & Albrechtsen, 1998). However, no further studies were made on viruses infecting these crops.

Citrus Crops

Viruses and virus-like diseases are among the major challenges of citrus production in Ethiopia. Tristeza caused by citrus tristeza closterovirus (CTV) is one of the very few diseases causing severe losses in citrus around the world. Symptoms in infected plants include dieback, general chlorosis, watershoots, honeycomb in bark and in some cases overgrowth of the scion over the rootstock. Symptoms such as honey combing just below the bud union, general chlorosis, die back stunting and sometimes water shoots were observed in various locations including Gibe, Erer Gota, Wonji, Sodere, Awarra Melka, Wondo Genet and Melka Werer (Schwartz 1976, Dereje et al. 1977, Van Bruggen & Almaz 1985). In few cases, the presence of CTV was confirmed by grafting to indicator seedlings (Dereje *et al.* 1977, Van Bruggen & Almaz 1985). CTV is transmitted by budding, grafting and several kinds of aphid vectors of which *Toxoptera citiricidus*, *T. auranti* and *Aphis gossypii* are implicated as vectors in Ethiopia (Tsedeke 1988).

Psorosis is a name given to a group of virus diseases collectively called citrus psorosis virus complex. The viruses involved in the complex include citrus ringspot virus (psorosis A and B), citrus leaf rugose virus (crinkly leaf component) and citrus variegation virus (infectious variegation component) (Brunt *et al.* 1996). Symptoms of psorosis A or scaly bark on young leaves include small elongated cleared spaces occurring in the region of the veinlets. In the case of concave gum, there are open concavities, usually diamond shaped on the trunk with the major branches of the trees having gum layers.

Symptoms including scaly bark, concave gum and blind pocket were recorded in several locations including Tibila (Upper Awash), Arba Minch and Koka (Dagnachew 1967, Chapot 1970, Dereje *et al.* 1977, Bar-Joseph 1990). Scaly bark (psorosis A) is the most common form in Ethiopia observed in sweet orange while concave gum is the next frequently observed type on sweet orange and mandarins; blind pocket is suspected to be present at some locations (Dereje 1979). Psorosis is mainly transmitted by budding and grafting. No insect vector is known.

Symptoms of exocortis and cachexia (xyloporosis), caused by citrus exocortis viroid (CEVd), and of citrus cachexia viroid (CCVd) respectively, were observed at various locations (e.g. Melka Werer, Koka, Erer Gota, Tibila and Urso), and in some cases confirmed by indicator test plant in the greenhouse (Dagnachew 1967, Dereje et al. 1977, Van Bruggen & Almaz 1985, Bar-Joseph 1990).

Most of the information about citrus virus diseases provided above is based on field identification based on symptoms and is not supported by laboratory studies. However, losses caused by virus diseases in citrus are suspected to be high although accurate data is not available (Dereje 1979). Currently, systematic research on citrus viruses is virtually non-existent particularly after virus indexing activities started by Van Bruggen & Almaz (1985) at Holetta Agricultural Research Center were discontinued due to lack adequate facilities and experience. There is particularly a lack plant pathologists/virologists dealing with viruses of woody crops that are studied using methodology somewhat different from that used for annual crops. There is an urgent need to fill this gap in manpower and facilities so that the exact identity of the causal viruses and the appropriate control strategies are worked out.

Unidentified Virus-like Diseases on Other Plants

Virus-like diseases were recorded in many other plants in the country, although the causal viruses were not accurately identified. Bos (1974) observed several banana (*Musa cavendishii*) plants showing chlorotic leaf striping and stunting symptoms resembling cucumber mosaic cucumovirus infection at Melkasadi. He also

recorded virus-like symptoms in papaya (*Caricum papaya*) at Metahara, yam (*Discorea* spp.) at Arba Minch and Soddo, and taro (Colocosia spp) and cassava (*Manihot utilissima*) at Melka Werer, and garlic (*Allium sativum*) at Holetta but no virus has yet been isolated and identified from these crops. Geremew & Asfaw (1992) reported that leaf curl and mosaic diseases suspected to be caused by viruses are becoming important problems in sesame. In sweet potato, filamentous virus particles tentatively identified as sweet potato feathery mottle virus were observed from leaves suspected of virus infection (SPL 1986). Among the ornamental plants, leaf crinkling is recorded in *Rosa abyssinica* from Harar (Stewart & Dagnachew 1967) while mosaic in *Canna indica* at Ambo (Bos 1974).

Future Prospects

The foregoing account of what is known about virus and virus-like diseases of plants in Ethiopia makes it clear that in the last few decades, considerable progress has been made in the area of virus identification. It is also evident that many virus-like diseases exist in different crops for which the exact identity of their causal agent is not accurately established. In many crops, virus identification is done based only on very few samples and without any data on field incidence. There are also crops grown in uncovered agroecologies with climatic conditions favourable for viruses and their vector populations. Survey activities should, therefore, be continued to monitor disease dynamics in previously surveyed areas and also identify viruses in yet uncovered crops and agroecologies. This will also help to clarify some of the contradiction about the relative importance of viruses in certain crops.

There is virtually no data on yield losses caused by virus diseases to define the importance of plant viruses in realistic and economic terms. However, some viruses in certain crops are already considered as economically important and thus given research priority mainly based on survey results (distribution, field incidence, etc). There is a need to substantiate such conclusions with reliable loss estimates so as to use the limited available resources more effectively.

Although the main purpose of virus research is to solve farmers' problem, there is no recommended technology forwarded to the users to control virus diseases. The available sources of resistance obtained on few virus diseases such as pepper viruses (Agranovsky & Mitiku 1986) and chickpea stunt (Mengistu & Negusse 1994) are not yet utilized by the breeding programs. There should be a strong collaboration between breeders and virologists in developing resistant crop varieties. For crops like pepper, which are seriously affected by viruses, host resistance could be considered as one of the important criteria for variety release. Currently, screening of crop genotypes is being conducted at Plant Protection Research Center, Ambo, for resistance to the major virus diseases like MSV on maize, FBNYV on faba bean and BYDV on barley. Such activities should be broadened to include screening under natural conditions at different locations in the country where virus strains affecting the respective crops may vary. Depending on the nature of the specific viruses, efforts should also be made on strengthening research on the manipulation of cultural and/or biotic factors, chemicals to control vectors and their integration to resistant cultivars to manage the major virus diseases of crops. For seed-borne viruses or viruses transmitted by vegetative propagation, the use of certified virus-free seeds or planting materials can be a feasible management option.

Since the knowledge of virus strains in an area is necessary for successful resistance screening program, the characterization of the Ethiopian isolates of major viruses to strain level using modern techniques such as monoclonal antibodies and molecular techniques should be done. Information on the type of natural vectors, their biology and population dynamics, and the role of alternate hosts and seed-borne inoculum which influence the development of virus epidemics in space and time are essential for the development of effective control strategies. This can best be achieved by a coordinated multidisciplinary research involving plant pathologists/virologists, vector entomologists and plant breeders with adequate training and modern facilities necessary for their specific areas of work.

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