VIRUS DISEASES OF RICE AND LEGUME CROPS IN NEPAL: STATUS AND FUTURE STRATEGIES

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ABSTRACT

Nepal, a small land-locked country, shows a wide spectrum of climatic variation due to the altitude ranging from near sea level to the highest peak in the world. The types of plant parasitic pathogens prevailing in Nepal reflect the diversity in the climatic conditions in the Kingdom. Twenty six diseases including twenty fungal, two bacterial, one nematode, one physiological and two viral diseases are known to affect rice (*Oryza sativa* L.) in Nepal, whereas sixteen fungal, three bacterial and three viral diseases of soybean have been observed in Nepal. The causal agents of two virus diseases of rice viz. rice dwarf virus and rice tungro virus have been identified. This paper briefly reviews the studies carried out on these two viruses in Nepal. Three viruses viz. soybean mosaic virus, the agent of bud blight (tobacco ring spot virus) and yellow mosaic virus of soybean (*Glycine max* (L.) Merr.), have been reported. Disease caused by yellow mosaic virus in mungbean (*Phaseolus aureus* Roxb.), proliferation (cucumber mosaic virus) and stunt (pea leaf roll virus) in chickpea (*Cicer arietinum* L.) and the disease caused by sterility mosaic virus in pigeonpea (*Cajanus cajan* (L.) Mll.) have been observed but their identification is solely based on the symptoms on plants. Major constraints on virological research in Nepal are discussed. Future strategies are outlined.

Introduction

Nepal is a small land-locked country situated between 26° 20′ N- 30° 10′N latitude and 80° 15′E- 88° 15′E longitude which lies on the southern slopes of the Himalayas (Fig.1). Its overall surface area covers 141,000km^2. The Kingdom has a cultivated area of about 39,276km^2 which accounts for nearly 28% of the total land area. Total population of the Kingdom is 16.17 million. The country is rectangular in shape with a total length of about 800km (East to West) and a width of 130-240km (North to South). On the basis of altitude, Nepal is divided into four regions. From the North, they are: (a) the Himalayan region (altitude varies from 3,660 to 8,840m* msl), (b) the mountainous region (600-3,660m), (c) inner terai region, and (d) terai region (below 600m). However, the country can be broadly divided into three parallel ecological zones extending from East to West, that is, the terai, the hilly region, and the Himalayan region (Fig.1). The terai region including the inner terai accounts for 17% of the total area whereas the mountainous region accounts for 64%. Nepal is bounded by China to the North and the remaining portion of the total area is bounded by India. The nearest sea is about 1,120km far from the Kingdom.

Due to the differences in altitude in the topography of the country, Nepal shows a broad range of climatic variation. It has a tropical, warm temperate, cold temperate, alpine and Himalayan climate. The temperature goes up to 43°C during the summer in the tropical monsoon climatic region. The mean annual rainfall ranges from 250mm to 6,000mm. The range of rainfall is 1,000 to 1,500mm over most of the country. Eighty to ninety percent rainfall occurs within four months, that is, from June to September. Since the monsoon runs from East to West, the eastern terai region receives more rainfall than the western region. The rainfall in the eastern terai region (Jhapa) is 1,750mm, whereas in western Nepal (Kanchanpur) it is only 750mm. In the hills, the rainfall varies from 1,200mm to 2,250mm.

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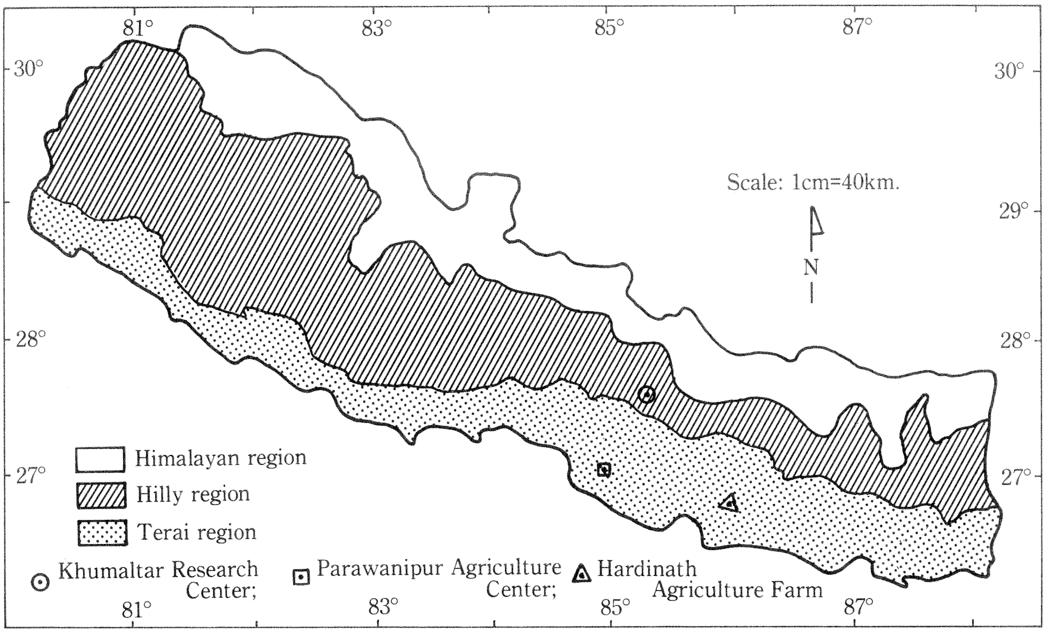

Fig. 1 Physical map of Nepal.

Status of rice and legume crops in Nepal

Since rice is the leading crop in the terai region, it ranks first as the cereal crop of the Kingdom (Table 1). It is grown from the altitude of below 100m (terai) to the altitude of 3,050m (Jumla valley) in Nepal. The altitude 3,050m is the highest point where rice is grown in the world. Rice is grown over 55% of the cultivated area of Nepal contributing about 59% of the total grain production. The terai region has accounted for nearly 80% of the total land area cultivated to rice in the Kingdom and produces approximately 75% of total rice grain. Total cultivated area under rice crop is 1,297,000 hectares with a production of 2,560,000 ton. However, the national yield is only 1.98 ton/ha (Table 1).

Table 1 Area, production and yield of major food crops in Nepal

S.N.	Name of crop	Area (1,000 ha)	Production (1,000 ton)	Yield (Kg/ha)
1	Rice	1,297	2,560	1,975
2	Corn	475	752	1,581
3	Wheat	400	526	1,315
4	Grain legumes	213	84.2	395
5	Millet	122	122	1,000
6	Oilseeds	114	79	695
7	Barley	27	23	863

Source: Agricultural Statistics of Nepal, 1983: Department of Food and Agricultural Marketing Services, HMG/Nepal.

Based on the cultivated area, grain legumes rank fourth among the major food crops in Nepal (Table 1). The contribution of grain legumes to the gross domestic product is estimated to be 1.5%. The total area under grain legumes is estimated to be 213,000 hectares with a total production of 84,200 ton (Table 1). Average yield is only 395 kg/ha.

Different kinds of grain legumes are grown in Nepal. However, from the viewpoint of cultivated area, chickling vetch (*Lathyrus sativus* L.), lentil (*Lens esculenta* Moench.), chickpea (*Cicer arietinum* L.), horsegram (*Dolichus biflorus* Roxb.), soybean (*Glycine max* (L.) Mer.), mungbean (*Phaseolus aureus* Roxb.), blackgram (*Phaseolus mungo* var. *Radiatus* L.), pegeonpea (*Cajanus cajan* (L.) Mill.) and field pea (*Pisum sativum* L.) are important, respectively (Table 2). Cultivation of chickpea, chickling vetch, mungbean and pigeonpea is concentrated in the terai region, and that of soybean, cowpea, blackgram and horsegram in mid-hills and valleys.

Table 2 Area, production and yield of major grain legume crops in Nepal

S.N.	Name of crop	Area (1,000 ha)	Production (1,000 ton)	Yield (Kg/ha)
1	Lathyrus	49.2	18.7	380
2	Lentil	44.5	17.0	382
3	Chickpea	34.3	13.1	381
4	Horsegram	20.7	7.9	381
5	Soybean	18.4	10.1	548
6	Mungbean and Blackgram	16.0	6.1	381
7	Pigeon pea	12.7	4.8	377
8	Field pea	11.2	4.3	383
9	Others	6.0	2.2	366
	Total	213.0	84.2	3889

Source: Unpublished data of Department of Food and Agricultural Marketing Services, HMG/Nepal, 1983.

Rice virus diseases in Nepal

Investigations on rice diseases in Nepal have been initiated since 1963–64. So far, of the 21 rice diseases occurring in Nepal, including major and minor diseases, 2 diseases caused by viruses viz. rice dwarf virus (RDV) and rice tungro virus (RTV) have been reported (Table 3) and the identification of the virus has been performed.

Table 3 List of rice diseases in Nepal

	Disease	Causal organism	Economic importance
Fungal			
1	Blast	*Pyricularia oryzae*	Major
2	Sheath blight	*Thanotephorus cucumeris* (FK.) donk.	Major
3	Sheath rot	*Acrocylindrium oryzae* Sawada	Major
4	False smut	*Ustilaginoidea virens (Ck.)* Tak.	Minor
5	Brown leaf spot	*Helminthosporium oryzae* Breda de Haan	Major
6	Narrow brown spot	*Cercospora oryzae* Miyake	Minor
7	Leaf scald	*Rhynchosporium oryzae* Has. and Yokogi	Minor
8	Stem rot	*Sclerotium oryzae*	Minor
9	Damping off	*Fusarium* sp.	Minor
10	Seedling blight	*Helminthosporium* sp.	Minor
11	Stack burn	*Trichoconis padwickii* Ganguli	Reported
12	Leaf spot	*Curvularia oryzae*	Reported
13	Black kernel	*Nigrospora oryzae* Hadson	Reported
14	Red blotch of grain	*Epicoccum purpurescens*	Reported
15	Gray mold of grain	*Cladosporium* sp.	Reported
Bacterial			
16	Bacterial leaf blight	*Xanthomonas campestris* pv. *oryzae*	Major
17	Bacterial leaf streak	*Xanthomonas campestris* pv. *oryzae translucens*/ f. sp. *oryzicola*	Major
Nematode			
18	White tip	*Aphelenchoides besseyi* Christie	Minor
Virus			
19	Rice dwarf virus	—	Reported
20	Rice tungro virus	—	Reported
Physiological			
21	Khaira disease (zinc deficiency)		Major

1 Rice dwarf virus

1) Occurrence in Nepal

John *et al.* (1978) reported the presence of dwarf-like symptoms in Nepal for the first time and confirmed the occurrence of rice dwarf virus in Khumaltar station, Kathmandu (John *et al.*, 1979a) on the rice cultivars KT 32-2 and Taichung 176. They found the same disease in farmers' fields in Kodari, Bhaktapur, Banepa and Parawanipur (terai). Previously, when V. T. John made surveys along with Dr. W. H. Freeman, Project Supervisor, ICP and Dr. M. H. Heu, Rice Breeder, ICP, in the hilly region in Godavari, Daman, Palung, and in the terai region in Janakpur, Hardinath and Parawanipur, they found that in most of the areas transplanted with the seedlings raised at Khumaltar the plants showed symptoms of dwarf disease. They also observed this disease in the farmers' fields in which locally raised seedlings had been transplanted. However, it can be stated that the rice dwarf virus (RDV) is prevalent in both major ecological region viz. hill and terai of the Kingdom.

2) Vectors for transmission

In Nepal, the rice dwarf virus (RDV) is transmitted only by *Nephotettix nigropictus* (John *et al.*, 1979a; Omura *et al.*, 1982). Among the other vectors known to transmit the rice dwarf virus, *Nephotettix cincticeps* and *Recilia dorsalis,* the former has not been reported in Nepal. Transmission is of the persistent and transovarial type.

3) Alternate hosts of the virus

Corn, wheat, barley, triticale and a grass, *Echinochloa* sp. have been tested with viruliferous vectors in the greenhouse at Khumaltar. In the case of *Echinochloa* sp., plants in the greenhouse showed typical symptoms. The virus was not recovered in *N. nigropictus* from *Echinochloa colonum* plants showing dwarf-like symptoms (Pradhan and Khatri, 1980).

4) Virus-vector interaction

Interaction of virus-vector was studied in the greenhouse at Khumaltar by Pradhan and Khatri (1980). The results are summarized as follows:

- Minimum acquisition feeding period of the virus by the vector was 30 minutes.
- Minimum infection feeding period by the viruliferous second and third instar nymphs of the vector was 45 minutes.
- Incubation (latent period) of the virus in the vector was four days or less.
- The nymphs showed a better ability of transmitting the virus than the adults.
- The virus was transmitted from one generation to another through eggs without further feeding on virus-infected plants.

5) Host-parasite interaction

Manandhar (1978, unpublished) attempted to analyse some of the host-parasite interactions and observed the following:

- No marked difference among male and female inoculation was noticed.
- Among 180 plants inoculated, 62 plants showed clear symptoms at different dates. Thus the percentage of infection was 35.
- Among all the test plants, the first symptoms of virus infection were observed 12 days after the first inoculation. It was also noted that the shortest time required for insects to inoculate a plant was 7 days.

6) Varietal resistance

John *et al.* (1979a) made several field trips and reported that rice varieties belonging to the indica, japonica, ponlais groups originating from India, Australia, Bangladesh, Brazil, IRRI, Japan and Taiwan (tropical and temperate region) were affected by characteristic symptoms of rice dwarf virus (RDV). Upadhyay and Lapis (1981) tested 44 entries for resistance against rice dwarf virus in Nepal. Out of them, seven entries designated as IR 20, IR 2071-627-1, IR C3707-117-2, IR 2797-125, Tetep, IR 1416-128-5-8 and IR 1905-81-3-1 showed 0.5% seedling infection. Other three entries named IET 2938, IR 1544-340-6-1 and IR 1905-P 11-29-4-1 showed 6–25% seedling infection. Remaining entries showed susceptible reaction to rice dwarf virus ranging from moderate to high.

7) Test for virus identification in Nepalese rice dwarf isolates

Omura *et al.* (1982) attempted to study in Japan the rice dwarf isolates from Nepal by electron microscopy and serological tests. By electron microscopy, polyhedral particles about 70 nm in diameter were observed. The size and structure of the particles were similar to those observed in rice dwarf virus in Japan. Serological test was performed by the double gel diffusion method. The size and structure of the particles and particle-plant cell relationships were quite similar to those of RDV in Japan. By these results, together with the symptomatology and etiological tests, they concluded that the disease was rice dwarf.

2 Rice tungro virus

1) Occurrence in Nepal

V. T. John had confirmed the presence of rice tungro virus (RTV) from the Khumaltar crossing block in the Kathmandu valley, as mentioned in his consultancy report. Later on, John *et al.* (1979b) reported the occurrence of tungro disease in Parawanipur in Nepal terai for the first time. They observed rice plants with symptoms characteristic of tungro in the early to midtillering stages at the Rice Research Station, Parawanipur (terai). In 1980, a disease with characteristic tungro symptoms appeared in Hardinath Agriculture Farm, Janakpur and its authentic identification as rice tungro virus complex was made by Omura *et al.* (1981).

2) Vectors and transmission

Both viruses, rice tungro and rice dwarf are transmitted by the same vector, *Nephotettix nigropictus* (Manandhar, 1978, unpublished). But this vector was not found to be effective in the transmission of the tungro virus (John, 1979). The species *N. virescens* is the most active transmitter of the tungro virus. Although there is no report of this vector in Nepal, John (1979) demonstrated the presence of *N. virescens* in Parawanipur (terai). A. causal examination of vectors clearly showed the predominance of *N. virescens,* the most efficient tungro vector (John *et al.,* 1979b). Transmission of tungro virus is non persistent and non transovarial.

The suspected plants from the crossing block at Khumaltar were brought into the greenhouse, and an attempt was made to transmit the disease through *N. nigropictus.* The disease could not be transmitted. It was, therefore, considered that either the disease was different from tungro or the vector was not effective in spite of the presence of tungro virus in the plant. The same dried samples taken to All India Co-ordinated Rice Improvement Project (AICRIP), however, showed the positive transmission of a weakly virulent strain of tungro, when *N. virescens* the main vector of the virus was used, which confirmed the presence of tungro disease in the Kathmandu valley.

The suspected plants from Parawanipur were also taken to the greenhouse at Khumaltar and inoculated through the vectors to Taichung 176 seedlings. Thirty percent of the seedlings were found to be infected within 10 days and the symptoms were similar to those described earlier (John *et al.,* 1979b).

3) Test for confirming the presence of virus in Nepalese rice tungro isolates

Electron microscopic studies of the Nepalese material performed in Japan revealed the presence of polyhedral particles about 30 nm in diameter and 100-300 nm long (RTSV) and bacilliform particles about 30-35 nm in diameter and 100-300 nm long (RTBV). The results showed that these two kinds of virus particles were associated with rice tungro disease in Nepal, as had been already reported in the Philippines, Thailand, Malaysia and Indonesia (Omura *et al.,* 1981).

Virus diseases of legume crops in Nepal

J. B. Manandhar, Plant Pathologist, Plant Pathology Division, Khumaltar and J. B. Sinclair, Professor of International Plant Pathology, University of Illinois, USA reported the occurrence of sixteen fungal diseases, three bacterial diseases along with three viral diseases viz. a disease caused by soybean mosaic virus (SMV), bud blight caused by tobacco ring spot virus (TRSV) and a disease caused by yellow mosaic virus (YMV) on soybean in Nepal (Table 4). The report was based on an extensive survey carried out in 1977, 1978 and 1979, and supported in part by the International Agricultural Development Service (IADS). They also observed seeds showing symptoms of infection with soybean mosaic virus (SMV). Diseases and their causal agents were identified using Koch's postulates. Since, no mention is made of any virological techniques adopted in the materials and methods, it is assumed that their identification might have been solely based on the symptomatology of the studied materials. The disease caused by soybean mosaic virus (SMV), as they reported, was observed in various parts of Kathmandu valley and was found to be of minor importance as far as the yield loss was concerned (Manandhar, 1975). Manandhar (1977) observed the disease caused by soybean mosaic virus in the trials in all locations (Kathmandu, Kakani, Bhairahawa, Parawanipur) and the disease was more uniformly distributed at terai locations than in the hills. He added that the disease was not severe. Manandhar (1979) reported that the diseases caused by bud blight virus and soybean mosaic virus were important diseases found in the best adapted variety Hardee (for terai) during a field trip to Sarlahi.

Table 4 List of soybean diseases in Nepal

	Disease	Causal organism	Economic importance
1	Pod and stem blight	*Diaporthe phaseolorum* (Cke. and Ell.) var. Sojae Wehm.	Major
2	Anthracnose	*Colletotrichum dematium* (Pers. ex Fr.) Grove var. *truncata* (Schw.), Arx.,	Major
3	Frog eye leaf spot	*Cercospora sojina* Hara.	Major
4	Rust	*Phakopsora pachyrhizi* Sydow	Major
5	Purple seed stain	*Cercospora kikuchii* (T. Matsu and Tomoyasa) Chupp.	Major
6	Brown leaf spot	*Septoria glycines* Hemmi.	Minor
7	Charcoal rot	*Macrophomina phaseolina* (Tassi) Goid.	Minor
8	Root and stem rot complex	*Fusarium* sp. and *Rhizoctonia solani* Kuehn.	Minor Minor
9	Sclerotinia stem blight	*Sclerotinia rolfsii* Sacc.	Minor
10	Seedling blight	*Pythium* sp.	Minor
11	Phyllosticta leaf spot	*Phyllosticta sojaecola* Massal.	Minor
12	Alternaria leaf spot	*Alternaria tenuissima* Needs. ex Fr.	Minor
13	Ascochyta blight	*Ascochyta phaseolorum* Sacc.	Reported
14	Leaf blight	*Corynespora cassicola* (Berk. and Curt) Wei associated with *Cercosporella* sp.	
15	Bacterial blight	*Pseudomonas syringae* pv. *glycinea* (Coerper) young, Dye and Wilke.	Minor
16	Bacterial pustule	*Xanthomonas campestris* pv. *phaseoli* (Smith) Dye.	Major
17	—	*Bacillus subtilis*	Minor
18	Soybean mosaic virus		Minor
19	Bud blight (tobacco ringspot virus)		Minor
20	Yellow mosaic virus		Minor

* Seed decay

Heavy infection of soybean mosaic virus was recorded in Williams, Calland, Forrest, Hardee, and Davis, whereas improved Pelican, Jupitar and Bragg varieties of soybean were found free from SMV (Manandhar, 1975). Joshi (1980) found 6 entries with yellow mosaic virus, 5 entries with bud blight virus and 21 entries with soybean mosaic virus out of 151 entries. However, these three viruses especially soybean mosaic virus (SMV) are being observed every year in the soybean disease screening nursery.

The disease caused by yellow mosaic virus in mungbean (*Phaseolus aureus*) was observed on the basis of symptoms in different trials conducted at Nepalgunj, Bhairahawa, Parawanipur and Khumaltar (Neupane, 1982; Shrestha and Manandhar, 1983, unpublished). Shrestha and Manandhar (1983, unpublished) found more infection of yellow mosaic virus in mungbean in the wet season than in the dry season, which was probably due to the presence of vectors during the wet season. Nene *et al.* (1985) observed diseases including proliferation (cucumber mosaic virus), stunt (pea leaf roll virus) in chickpea (*Cicer arietinum*) and the disease caused by sterility mosaic virus in pigeonpea (*Cajanus cajan*).

Steps taken in the control of virus diseases

V. T. John (1979) suggested a regular monitoring on the occurrence of the respective vectors which can be killed by any one of the effective insecticides (carbaryl, carbofuran, citrulline, etc.) at the rate of 1.5kg ai/ha, if there are two visible insects on plants for rice tungro virus (RTV) and one for rice dwarf virus (RDV). He added that the elimination of infected plants and clean cultivation practices would be helpful.

In general, systemic and contact insecticides like methyl demeton and methyl parathion, respectively are recommended and used for the control of sucking type insects, viz. hoppers and aphids. Insecticidal control of vectors is the only method adopted in Nepal under the current conditions.

A common practice is the removal of virus-infected plants to reduce the inoculum potential.

As far as the varieties resistant to the virus diseases are concerned, no systematic screening programs are being implemented in this field. Several screening programs, conducted against *Nilaparvata lugens* have directly contributed to the reduction or control of the spread of the disease.

In order to prevent the entry of destructive diseases, the Plant Protection Act, 2029 has prohibited the importation of paddy seeds from countries where virus diseases like hoja blanca had been reported to occur.

Constraints on research on plant virus diseases in Nepal

The Plant Pathology Division which forms the nucleus of plant pathological research in Nepal, is composed of research laboratories dealing with mycology, bacteriology, nematology, seed pathology and toxicology along with VIROLOGY. Although there is a virology laboratory with few facilities in the division, no systematic attempts for further progress have been made in this field, due to the following factors:

- Lack of well-equipped laboratory in reference to virological work,
- Lack of manpower adequately trained in virology and
- Emphasis on other research priorities.

The Plant Pathology Division possesses laboratory facilities for preliminary work in plant virology. Besides this, a spectrophotometer and ultracentrifuge facilities are available. These facilities are not actually utilized and there is no separate well defined virology unit in the division. Outside the division, the Institute of Agriculture and Animal Science (IAAS) Rampur, Central Veterinary Hospital, Kathmandu, and Department of Botany, Tribhuvan University, Kirtipur also possess a few other laboratory facilities. However, there is a lack of collaboration among these institutions.

At present, the division has only one plant pathologist with some training in plant virology. Due to other responsibilities, he is unable to devote full time in virological work. Few trained staff members in virological methods are available in other institutes and are interested in this field.

Future of virus diseases of and legume crops in Nepal

A large number of hoppers are reported to be prevalent in rice plants in Nepal. They are: *Nilaparvata lugens, Sogatella furcifera, Nephotettix nigropictus, Recilia dorsalis, Deltocephalus* sp., *Kolla mimica, Cicadella spectra, Kolla raja, Cloria puncta, Delphacodes striatella, Exitianus capicolla* (Sharma and Mathema, 1977). In addition to this list, John (1979) reported the presence of *Nephotettix virescens* in Parawanipur. Fortunately, there is no record of frequent occurrence of rice dwarf virus and rice tungro virus in spite of the significant presence of vectors. Since the occurrence of the hoppers *Nilaparvata lugens* as the vector for grassy stunt, ragged stunt and wilted stunt virus, *Nephottettix* sp. for rice dwarf, tungro and yellow dwarf virus and *Recilia dorsalis* for gall dwarf, tungro and orange leaf virus, has been reported in other countries (IRRI, 1983), it can not be ruled out that their occurrence may not affect Nepal in future. Therefore precautions should be taken because the vectors may exhibit their viruliferous nature and cause epidemics of diseases at anytime.

Sogatella furcifera and *Nephotettix nigropictus* are economically important pests of rice in Nepal. The former one, *S. furcifera*, does not transmit any disease (IRRI, 1983). *Nilaparvata lugens* had been first reported in Nepal in 1965, but the extent of damage had not been recorded. However, Pradhan (1980) recorded infestations ranging from 200-400 insects/hill in the Kankai Agriculture Farm (eastern terai) in 1977 and 1978.

Observation of a large number of virus diseases, on the basis of the symptomatology in legume crops poses a major challenge to the production of healthy seeds in Nepal and the country may have a significant problem of viruses in legume crops in near future. The potential vectors such as *Acyrthosiphon pisum* in pea (*Pisum sativum*), *Aphis craccivora* in cowpea (*Vigna ungulata*) and *Aphis fabae* in broadbean (*Vicia faba*) are commonly encountered and reported in Nepal. Gyawali (1982) reported the presence of two aphids, *Aphis glycine* and *A. gossypii* and whitefly (*Bemisia tabaci*) in soybean. In this context the authors are not very hopeful that these potential vectors will remain innocuous. In the long run the situation may change because of the possible appearance of viruliferous vectors on the crops. It is thus suggested that a program to control these potential vectors should be implemented before the situation becomes uncontrollable.

Future strategies

The main constraints have already been discussed. To overcome them, the following recommendations are being made:

- Establishment of a well-equipped central virology laboratory in the Plant Pathology Division with adequately trained manpower.
- Establishment of equipped virology laboratory in educational institute (Tribhuvan University).
- Establishment of general virology laboratory in Agriculture Research Station as required.

Along with this infrastructure, the potential strategies include:

- Systematic survey of virus diseases,
- Collection, maintenance and preservation of virus diseases for future reference and use,
- Studies on properties of viruses as detailed as possible (biological/intrinsic),
- Studies on epidemiology and economic losses due to virus diseases,
- Regulatory control to prevent the spread of diseases (plant quarantine/seed certification),
- Studies on manipulation of cultural practices to reduce the incidence and severity of viruses,
- Develop possible control measures (chemical/physical),
- Use of host resistance to develop virus-resistant varieties (germplasm screening/breeding).

Besides this, collaborative projects with specialized virological laboratories in developed countries should be promoted.

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Discussion

Mochida, O. (IRRI): Is dwarf equally detected in farmers' fields and in experimental farms? Do you consider that there is a major risk that dwarf may become a very important disease in future?

Answer: Dwarf is sporadically detected in farmers' fields. I believe that dwarf may become an important disease in future as we cultivate varieties from other countries and the vector is present in Nepal. Also the weather conditions are conducive to the occurrence of the disease.

Omura, T. (Japan): Since dwarf disease occurs in Nepal as well as in distant countries including China, Korea and Japan whereas tungro disease may have been introduced to Nepal from neighboring countries such as India and since dwarf was first recorded in the highland areas and subsequently in the terai region, I wonder if you have any information about the spread of virus diseases in relation to vector movement associated with the direction of the wind.

Answer: I can not answer your question due to the lack of epidemiological studies on these diseases.