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Review Article

PREVALENCE OF POTATO LEAF ROLL VIRUS DISEASE IMPACTS AND SEVERAL MANAGEMENT STRATEGIES TO HALT THE DAMAGE

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Abstract: *The lethal and widespread potato leaf roll virus (PLRV) is found in many potato farms. It not only leads to worldwide yield loss, but also to yield loss in Pakistan. The appearance of symptoms distinguishes both primary and secondary illnesses. Pathogen management methods follow pathogen detection systems. Furthermore, environmental factors contribute to the development of disease prediction models, which aid in the development of strategies to protect crops from viral infection. This article provides an overview of potato leaf roll virus damage, prospects and several management strategies to control it.*

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Introduction

Many crop breeding programs are concerned with There are many viral diseases (mosaic, stunted, necrosis, leaf rolling and etc.) which causes losses in yield. Among all the diseases of potatoes the most destructive disease of potato is leaf roll virus disease. Its vector is green peach aphid *Myzuspercicae* which transmits the disease. Potato leaf roll virus cause huge yield losses of potatoes every year. About the forty viruses are responsible to infect the potato crop. The potato leaf roll virus is the most common potato virus disease that causes serious damage every year in many parts of the world. It damages the potatoes field in many patterns (Wang *et al*., 2006). PLRV potato plants are infected when a healthy virus which is transmitted by aphid vectors, especially green peach aphid (GPA), *Myzuspersicae*. One of the general control methods is to control aphid vectors by spray in a preventive manner (Bergervoet *et al*., 2008). At the beginning of this century, the causative agent of this disease was considered a virus based on the results of a transplant. It was later discovered that the agent was transmitted by tick vectors. Potato vegetation has a significant effect on the epidemiology of viral diseases and has resulted in the use of terms that are different in meaning from those commonly used in plant pathology. Tubers (seed potatoes) can be infected due to systemic movement of viruses following infection of the mother plants during the previous harvest period, or by virus during germination. Plants emerging from these tubers are said to show signs of "secondary infection". Infected "soil" tubers that survive the winter months can also produce "volunteer" plants that can be viral. Thus, the initial rate of plant infection plays an important role in the spread of the aphid-borne virus (Chung *et al*., 2016). Members of the Solanaceae family are the main PLRV machines Non-solar machines belong to nine plant families and have also been considered PLRV hosts. These nine plant families are as: Chenopodiaceae, Brassicaceae, Malvaceae, Asteraceae, Cucurbitaceae, Lamiaceae and Portulacracea. Datura spp. and *Physalis floridana* are considered excellent analyzes and the increase in hosting respectively. PLRV acquired and transmitted by aphid vectors and methods associated with PLRV are circulatory, non-proliferative and persistent PLRV is restricted in flow cells and therefore required more time to acquire aphids (Agindotan *et al*., 2007).

Non-viral aphids can get viruses from such stem sauces and infect other plants. These "current seasonal infections" describe "primary symptoms" that are often different from those of "secondary infections". They can themselves become the controllers for the further spread of viruses. This process is equivalent to over-distribution in many other plant systems. As PLRV is transmitted continuously, the minimum access time for acquisition and sowing requires approx. 1 hour each is possible to reduce its spread by using insecticides.

In Scotland, insecticides in Scotland reduced the prevalence of PLRV by a quarter or less in control sites. In Japan, Nelson Mandela first mentioned the disease, but Abdul Wahab reported experiments on the infection of the virus on tubers, using paste, saponification and aphid vectors (Wang *et al*., 2006). Various strains have been identified for most of these viruses, initially based on the type and severity of the symptoms they cause in potatoes or other plant species and then on serum or molecular characteristics. Plant viruses such as potato virus Y, potato virus (PLRV), potato virus A (PVA), potato virus S (PVS), potato virus M (PVM) and potato virus X (PVX) have been reported in these potatoes' growth area. Among all potato viruses, PLRV has been considered a major threat in potato production. PLRV is a species of the genus Polerovirus and the family Luteoviridaecae. The isometric beam tube has a diameter of 24nm (Bergervoet *et al*., 2008). This virus is positive sense single stranded RNA which have 5.9 kb genome. The epidemiology of aphid-transmitted plant viruses depends on many ecological factors the temperature and relative humidity also influence the disease incidence of disease (Chung *et al*., 2016).

Characteristics primary symptoms includes the curling of leaves, yellowing and young leaves becomes leathery and very stiff. The corners of the young leaves become leathery and crunchy. They become very hard and chlorophyll pigment also reduces from the green fleshy part of the potato plants. Caused by PLRV consist of pale and curling young leaves, especially at the base, with an upright habit. The corners of some young leaves become blue. Many other symptoms caused when the growers sow the infected seed tubers the symptoms become very clear and cause huge yield losses. The leaves from the base becomes stiff and sheading of potato leaves occur. ELISA was mostly use in the detection of PLRV in the potato seed tubers. Accumulation of some carbohydrates in the leaves show the disease in the plants. More than two to three times more carbohydrates are present in diseased leaves. Carbohydrates sometimes accumulate in the leaves two to three times more than in healthy leaves. When more amount of these nutrients is present in the leaves there could not be transmission of other plant materials, so the result is the death of the plants. PLRV causes very huge and significant economic losses in many countries of the world (Agindotan *et al*., 2007). The biggest loss due to PLRV is the formation of spotted nodules that have been transformed into tubers, called net necrosis (NN), which leads to a decrease in quality and price. There are number of tubers of susceptible varieties of infected plants have symptoms which are expressed in the field. Healthy plants can be stored for long times in cool temperature (Novy *et al*., 2007).

Although evidence has suggested that aphid alarm pheromone (EF) may increase apteral distribution as well as winged individuals to affect aphid abundance. Early news of the potato virus focused on the 'population' of aphid species that colonized and reproduced on potato plants. The infectious properties of PLRV are different from other potato lice infestations. PLRV is only transmitted by aphids persistently, while PVY, PVA, PVM, PVS and PVV can be transmitted mechanically or by aphid in a non-persistent manner. Infection affects environmental factors, in particular temperatures, which can alter aphids during behavior and or sowing. The use of EF does not significantly reduce the efficiency of virus transmission. PLRV is only potato virus that has been successfully controlled by the use of insecticides because of its persistent (long term) life cycle (Peiman & Xie, 2006).

There are many species of aphid which are responsible for natural transmission of the potato virus. Among these aphid species, the green peach aphid (*Myzuspersicae*) is the most efficient vector that transmits PLRV with persistent, circulatory and non-proliferation. The virus is a highly restricted virus and is also transmitted through transplantation. The prevalence of *M. persicae* in Pakistan was first reported in 1978. PLRV has been a growing problem and widespread in all potato growing areas in Pakistan. Infected plants develop visible symptoms that include upright character and rolling of the leaves, interfering with chlorosis, leathery leaves, flooding necrosis, stunting of the plant and cyanosis in tubers. There is no effective extreme resistance to PLRV in potatoes PLRV causes potato leaves to turn yellow and yellow, which later becomes dry, stiff, leathery, crisp and papery to the touch. PLRV also causes mesh in potato tubers and poorer crop quality. In Pakistan, yields of up to 90% have been announced due to PLRV (Basky, 2002).

The biggest loss due to PLRV is the development of a junction or cross-linking of discolored tissues in tubers, called network necrosis (NN), which leads to a decrease in quality and price. Not all tubers from an infected plant develop sensitive NN crops and the time of NN expression varies. Potato tubers that are not lethal to harvest can be stored as it is. Infection of PLRV occurs when healthy potato plants are infected with salmonella virus, mainly green peach lice (GPA), *Myzuspersicae*. A common management practice is to control aphid vectors in the field with insecticide prophylaxis (Srinivasan & Alvarez, 2007). The recent reintroduction of aldicarb (Temik) into the insecticide market gives potato farmers the choice of using insecticides before or after emergence, or multiple use of insecticide leaves sprayed during the growing season. The purpose of this study is to explain application decisions using experimental data from a central production area in Washington to establish an experiential relationship between the probability of tubers expressing NN (in different fixed storage periods) and the time after planting for sowing related varieties (spacing of seeds). Identifying the sperm failure with the highest probability of NN is an important first step in establishing an optimistic time plan that uses insecticides when they are most effective and reporting their use when they are inactive. Such an optimization allows potato growers to minimize the use of pesticides with acceptable production risk (Ahmadvand *et al*., 2012).

Historical background of PLRV

Potato (*Solanum tuberosum* L.) is native originally to mainland America. About 7000 to 9000 years ago, as a wild plant it is used to grow. During early 17^{th} century, Portuguese introduced Potato to India. Potato (seed) exported to Nepal followed by Sri Lanka followed by Oman followed by Mauritius followed by Kuwait. Including Potato and tuber crops, the compound annual growth rate (%) of vegetables is 7.0. Total quantity of potato exported from India is 384.24 thousand MT that value in Indian currency 64,056.48 lakh rupees (2016-17). India ranks fifth in production area in the world. Potato is grown almost throughout the country in India major states which are producing are West Bengal, Bihar, Uttar Pradesh, Madhya Pradesh, Assam, Punjab, Orissa, Karnataka, Himachal Pradesh, Meghalaya, Maharashtra and Gujarat. Potato is temperature region crop basically. Potato is planting in almost every state under every condition which makes it possible to see the crop in field round the year in one part or the other in India (Cárdenas *et al*., 2017).

However, potato yields rise in the sub-tropical plains of India when the maximum daytime temperature is below 33°C and the overnight temperature does not exceed 20 ° C. macronutrients and nutrients, plant hormones, stimulants and other useful substances (Li *et al*., 2013).In agro-ecological region, most of the farmers are not supplying balanced nutrients, particularly macro and micronutrients to the crop and there is a possibility to loss of nutrients in soil for its acidic light texture soil and heavy rainfall. Hence, there is an urgent need to standardize the balance nutrient composition by incorporating secondary and micronutrient sources considering its amount of requirement (Kotzampigikis *et al*., 2008). Two research trends on PLRV have emerged, one of which is research on the relationship between virus and vector, in particular, virus multiplication in the vector, and other research on virus characterization. This investigation is in line with and uses recent developments in purification techniques in addition to the application of the biomass method (Yi *et al*., 2014).

The virus used in this study was isolated from a stem of a weak Hokkaido Agricultural Cooperative in Hokkaido. The PLRV isolate was cultured in *Physalis floridana* RYDB. Plants, which show different symptoms after sowing with viral aphids. Shoots *P. floridana* first showed chlorosis 7-10 days after insemination. Then there is chlorosis between the blood vessels in the lower leaves, which become coarse and roll slightly. The infected plant is only clogged. The plant *P. floridana* has been widely used as a test plant (Kushnarenko *et al*., 2017).

The seeds of this plant were sown in vermiculite and the plants were planted in a 10 cm pot when the second or third leaf developed. Plants for wire cultivation or aphid cultivation were transferred to 12cm pots. The plants were grown in greenhouses from 1961 to 1966 and in greenhouses at temperatures (26°C) from 1967 to 1970. The potato virus (PLRV) causes economic significant losses in production of potato US and it is identify as the very essential problem which the industry face (Kostiw, 2011). Some physical characteristics are described, the distinction and purity of PLRV from plants, and local pathogens and plants. This study was conducted for 10 years between 1961 and 1970 in Sapporo, Japan, Department of Botany, Department of Agriculture, and Hokkaido University. The research is approved by the Hokkaido Foundation of science, the Ministry of Education Science Foundation, and the Matsunaga Science Foundation (Bostan *et al*., 2006).

Eersteling and Eba varieties demonstrated formation of fewer tubers as the temperature was raised. It is proved that the leaf spray combined of zinc (10.00ppm) and manganese (10.00 ppm) it shows the height of plant higher, tubers, leaves number, yield, tuber weight, TSS content, carbohydrate content and protein content other treatments compared with. Therefore, these two small substances (manganese and zinc) can be recommended together with the usual doses of the main nutrients to potato growers to get higher yields and to prevent losses and increase the total production of potatoes (Mortimer-Jones *et al*., 2009).

Some varieties showed a reduction in tuber weight and yield with increase in temperature above 16°C. The foliage growth being encouraged, by increased temperature at the cost of tuber weights. Heat tolerant clones perform quiet economically than other heat sensitive clones in Peshawar. The DTO-28 has common yielding ability under hot as well as cool conditions. Some clones selected from the population produced satisfactory and relatively stable yields in both warm and cool environment. High temperature reduce yield in varieties and the response is different for different varieties. Average weight of tuber increased as the night temperature decrease in two varieties.Currently, about 40 plant viruses are known to be transmitted continuously by tick vectors. The most studied virus is Potato leaf roll virus (PLRV) (Abou-Jawdah *et al*., 2001).

Although much research has been done on virus transmission since 1922, there is little information on the nature of the virus due to the lack of a bioassay method as it cannot be transmitted from plant to plant by saponification. In 1955, Heinze tried to inject the aphid vector and advocated the use of technology to study persistent aphid viruses. Subsequently, many employees confirmed the usefulness of his technique in experiments on aphid-borne plant viruses(Faccioli & Colalongo, 2002).

Symptomology

Foliage symptoms

In foliar symptoms leaves curl upward, stunted growth mostly plant height and shoot length also reduced in this infection of PLRV. All the growth and yield parameters were improved significantly. The highest numerical value of plant height 23.55, 28.43 and 33.89cm at 45, 60, and 75 DAPS respectively. Tubers total number per plant (4.48), Tuber total yield (233.53g) per plant, yield per plot (14.07kg), yield per hectare (22.52t/ha) recorded with the sole application treatments of foliar application of Magnesium (Mg). Highest number of plant height 25,87, 31,33 and 36,71 cm, at 45, 60, 75 DAP, tubers total number per plant (8,18), tubers per plant total yield (346.80 g), total yield of tubers (23 , 04 kg), the total yield of tubers (36.87t / ha) was recorded using leaf application of sulfur (S), magnesium(Mg), boron (B) and zinc (Zn) (Zhang *et al*., 2017).

Tuber symptoms

The most important and significant symptoms of potato leaf roll virus on the tubers includes lesions on the tubers, reduced size of tubers. Mostly the skin of the tuber becomes very thin and perishable. Therefore, we cannot store such tubers for long period of time. Also wrinkled shapes of tubers and the taste of the tuber also changes. It becomes very susceptible to other pathogens. Above given are the symptoms of tubers. On the other hand, DAY (1955) first used homogeneous virus locks as inoculum. He found that the pill obtained by centrifugation uniformly from viral slaughter at 100,000 g for 30 minutes was contagious. It is also confirmed that homogeneous viral lice were contagious and a good control virus for injection into aphid vectors (Wang *et al*., 2011).

Distribution of PLRV

Potato virus Y (PVY) A) Biological properties of PVY was first discovered in *S. tubersum* in the United Kingdom. PVY is distributed worldwide. Some PVY strains are restricted to certain continents, e.g. PVYO strains occur worldwide, PVYC strains occur in Europe, Australia and India and PVYN strains occur in Europe, South America and Africa. In Pakistan, the virus was first isolated by Mirza and spread throughout the country. The most common economically harmful viruses that infect potato crops around the world are PVY and PLRV. PVY causing severe loss of potatoes is the most important among potato viruses. In Pakistan, the incidence of PVY is 2-25% and losses have been estimated at 40-70%. Significant crop losses for potato crops have been caused by PVY in Pakistan. PVY belongs to the genus Potyvirus. It is the most economically important and largest genus of plant viruses(Chatzivassiliou *et al*., 2008).

General characteristics:

The suitable weather conditions for appearance and buildup of PLRV include favorable temperature high RH, frequent rains and foggy/ cloudiness. In some cases, PLRV can result huge losses which might be as high as 80 per cent. In field tests for resistance. The variety 'Kiwitea' had shown high resistance to disease, possibly through inherited causes. At Modipuram, in Khrif crop season a better yield was noted in the late planted crop both for Kufrijyoti and Kufri chipsona-1. Disparate Kufri Jyoti and Kufri chipsona-1 has good resistance to PLRV. Yield potential of KufriPukhraj both in the early and late harvest, and its resistance to early and PLRV, this variety would prove to be a proper replacement for Kufri Chandramukhi, an early and PLRV vulnerable variety, and of Kufri Badshah and Kufri Bahar for the main crop. Kufri Pukhraj showed higher level of resistance to PLRV compared to Kufri Badshah a popular variety of the Northern-western plains in India. Kufri Surya also has modest degree of resistance to late blight. Among several biotic and abiotic factors that limit potato production in hills, PLRV caused (Chatzivassiliou *et al*., 2008).

Epidemiology

Mostly, the virus infection enhances when the temperature and humidity in the atmosphere is high mostly in rainy season. In rainy season aphid's population increases in a rapid manner which is a main vector for the spread of the disease. In this experiment, the current author also managed to infect the virus by injecting green peach aphid with extracts from weak plants and homogeneous or blood from viral lice, *M. persicae*(Novy *et al*., 2002). The transmission rate of aphids was too low to compare with inoculated from different handlebars and prepared differently. *A. solani*was also sown after injection with extracts from infected plants and viral salmon. However, this aphid species does not appear to be a suitable vector for injection despite its large size due to its high mortality rate(Gul *et al*., 2013). Furthermore, *P. floridana* seedlings (test plants) infested with *A. solani* aphids often withered.

Therefore, green peach aphid, *M. persicae*, were used as vectors for injection analysis in the following experiments. Since 1985 it is reported that *M. persicae* rarely transmitted the virus within 20 hours of injection, in many cases aphids were sprayed on separate leaves for 24 hours at room temperature and then transferred to a test plant. However, a few injected aphids transmitted the virus within 24 hours. After injection when the aphids were transported to test stations immediately after injection. Stegwee and Peter (1961) suggested that the presence of PLRV in the blood could be detected approximately eight hours after the feeding of alcohol and that after the first infection of the virus in the blood, another eight to sixteen of them were needed before the aphid could transmit the virus. Accordingly, when the virus mixtures are injected into the abdomen of aphids, aphids can become infested 8 to 16 hours after being injected (Abbas *et al*., 2016).

Potato diseases

Late blight disease is a potato disease which is infected by *P. infestans*, the most and very important disease of potato which base on the number of entries recorded in literature which is databases (Chung *et al*., 2013). An Annual yield causes a loss of $ 6.8 billion in potatoes and breakouts can has a worldwide impact, as we say in the potato Irish famine of 1846-1845, for example.Viral diseases in potatoes are the most worrying in Europe, where a serious condition called "curling" occurred in the mid-18th history in Ireland and England. The crop is attacked very much that growers left the crop. After some time, the degeneration is describing the mixture of disorders, of which the balloon is the main ingredients.The loss of crops caused by leaf disease was not as severe as the late famine in Ireland. However, is the effect and causes of the disease were widely discuss in the scientific and political spheres (Dhital *et al*., 2008).

PVY

PVY is belongs to genus potyvirus and family is potyviridae. For the first time in the history, it was isolate from potatoes with the help of aphids. Also, observed the process of cell freezing in the leaves of potatoes in mosaic of leaves and he named the phenomena Body-rich corpse. In present times PVY is very harmful for the potatoes and this disease is present every place where the potatoes have been grown (Nolte *et al*., 2004). On the leaves of the potatoes the PVY cause various symptoms depending upon the cultivars, climatic conditions and time in which this disease attacks more destructively. Mostly the plants which are attacked by this virus develops mottling of young leaves and sheading of potato leaves occurs. The color of the leaves becomes yellow and show the symptoms of necrosis. Leaves of the potato plants becomes crinkled and causes heavy yield losses in every year. We can calculate the average yield loss by using the following formula (Lapwood and Harris, 1982) the estimation of yield losses is about 40 Billons which is a remarkable value and have a huge impact on the GDP of the country. In addition to losses the main tuber quality decreases and ultimately very low prices in the market. Potatoes are grown in everywhere on the planet earth. It is the staple food of many countries. It is also grown the home gardens and in the small pot in many homes as vegetable. PVY disease have a large number of their host and very difficult to eliminate the disease so to control the damage due to this disease we should take very good management practices. Aphids damage the crops in persistent manner. When an infection occurs in the fields the PVY form patches in the fields and spreads in every plant of potatoes. It is very difficult to manage the damage due to PVY when it attacks on the potato fields. It is very difficult to control (Djilani-Khouadja *et al*., 2010).

The virus-resistant strain of the virus (PLRV) is Polerovirus and the Luteoviridae family. Symptoms of primary PLRV disease include chlorosis, swaying growth at the base of the stem and looking at all plants. Plants grown in tubers because serious disease stunting and popping of basal leaves. Necrosis can arise in the tissue phonethe upper part of plants and tubers (net necrosis) especially in clothes like ‘Russet Burbank’ or ‘Green Mountain’. Due to the poor behavior of the phloem transport of carbohydrates and the tubers of plants with PLRV disease are greatly reduced, and the yield can be reduced by 34-51%. Compared to PVY, PLRV has a narrower host area associated with Solanacae species, such as, *D. tatula*, *Physalis floridana* (test type), *S. nigrum*, *S. villosum* or *S. paniculatum*(Abbas *et al*., 2012).

Once insect bites are rare in potato production and today, PLRV is classified as the most serious tuber culosis and degradation of virus in size. Over the past 30 years, the need for PLRV has diminished largely due to the implementation of quality potato production policies in many countries (Eigenbrode *et al*., 2002). In addition, the control of aphid vectors has been successful due to the use of systemic insecticides. One of the neonicotinoids, developed in the late 1980s, today is that the insect spread worldwide and accounted for 27% of the total market value of 6.330 Euros in 2010. PLRV is a mild phloem virus and is transmitted by aphids permanently. The aphids die after the introduction of insects continues before the virus reaches the fluid which transmits the virus to the salivary canal and thus to the phloem cells. So the insects that organize their name have made great contributions to reduce the benefits of PLRVs over the last 30 years (Fang *et al*., 2005). However, in the past it has been repeatedly stated that there are few side effects of PLRV does not apply common symptoms to some cultivars, especially if the plant is lately sown (Davis & Radcliffe, 2008). This can lead to an unknown PLRV infection that has a seed risk production, when plant information and pathogens are not detected. PLRV is considered to be one of the most popular plant viruses. Increase in winter heat helps the survival of aphid bacteria and secondary growth of potatoes plants are the main source of inoculums (Zhu *et al*., 2006).

For Germany, meteorologists recording and predicting an increase in average cold temperatures in the year from summer dehydration due to climate change. Therefore, it can be assumed that it exists and the rate of PLRV transmission will increase over the next decade since positive results the relationship can be shown by the temperature and the size of the aphid mass, which is present turn related to the frequency of PLRV transmission (Li *et al*., 2018).

Disease development

Potato ranks fourth among food crops in Pakistan. Although Pakistan's potato production has increased, its yield per hectare is small compared to other potato countries. The use of fast-food fast food is increasing day by day, which is increasing the use of potatoes as a working product. A new manufacturing industry has been developing in Pakistan in recent years. The main obstacle to the growth of the potato industry is the lack of good infrastructure for processing. In Pakistan, the number of varieties required for processing is reduced by the actual yield and life if one or two varieties of potato depend on the industry to grow rapidly, thus gaining access to the quality of the equipment (Bekele *et al*., 2011). At present, there is no developed region that will have the attractive characteristics of agriculture to meet the needs of the national planning sector. Development and promotion of different varieties with good storage and processing can provide safe storage for other opportunities created during the full assembly period, thus reducing harvest damage and raising associated costs. With this in mind, we have now worked on choosing a new type of potato of a beautiful character in terms of good growth, nutritious quality, non-existent life, fresh distribution, and grinding, cooking, and cooking. Thirty-two species, including varieties grown in Pakistan (Desiree, Cardinal, and Diamond), have been re-examined for specific features at the National Agricultural Research Center in Islamabad (Were *et al*., 2013).

Management

Foliar application of different chemicals is applied on the infected field. Discard the infected plants from the field and burn them away from the field. Different chemicals such as boric acid, magnesium sulphate, copper sulphate, zinc sulphate and their various combination can be applied on the infected field to manage the population of aphid vector. Also use different insect trap methods to minimize the population of green peach aphids which are responsible for the spreading of potato leaf roll virus. Also use multiple cropping symptoms to eradicate the infections of virus from the field (Singh *et al*., 1996). The results of the present study have a significant difference between genetics in terms of genetic variation. Seeds slightly higher than genotype 394021-120. Experiments of processing / quality showed that starch content in dry matter and sugar reduction were low at NARC 1-2006 / 1, although the highest protein content was NARC 1-2006 / 2. Correctional studies showed that dry matter showed negative and reduced sugar. The longest idle time is NARC 393574-61 in environmental protection and the lowest total loss is NARC 393574-72. In cold storage, the NARC 393574-61 genotype exceeds other genotypes, indicating little absolute loss (Robert & Bourdin, 2001). In terms of organoleptic properties, the results of the panelists show that genotype 394055-40 in boiled and fried potatoes in VR 90-217 on page, VR 90-217 and NARC 1-2006 / 1 in French frying is better. In this experiment, we consider models 394021-120, NARC 1-2006 / 1, 393574-61, VR 90-217, NARC 2002-1 and 9625 to be suitable for better yield, based on their better performance all in all, new distribution, storage and processing to increase farmers 'income and meet the needs of the industry (Were *et al*., 2013).

Physiological Aspects

Crop growth and yield are dependent on physiological characteristics. The morphological features of potato varieties are influenced by environmental factors to a large extent. The growth and development of the potato plant differed noticeably during the two crop seasons. The continuous growth of the top during the main crop (spring) was in fact at the cost of the tubers which were initiated later than in autumn and developed slowly. Increase in soil and air temperature, sunshine, longer day length, as compared to those obtained in autumn, favored haulm growth and increased dry matter production, but negatively affected economic yields. In North Africa autumn is warmer than spring season. In the autumn there was more growth than the spring season as a result yields in the spring season were more than in the autumn. Early and enhanced ground coverage is some of the major reasons for higher tuber yields of riverbed cultivation in Gujarat(Sertkaya & Sertkaya, 2005).

Plants of almost all cultivars produced from small tubers have a little final ground cover and do not attain ultimate ground cover. At the Tarnab Farm of Pakistan, soil coverage was more than 80 percent for DTO-28 at about 75 DAP and reached 80 percent for Russet Burbank, Desiree and LT-1 at about 90 DAP. Percentage of soil coverage decreased rapidly after that time. Early canopy development is necessary 46 factor for high productivity in the spring crop when crop duration is short. This point out that conditions during the spring crop in Pakistan are positive for potato clones with determinant type growth habit. High temperature stress is a key factor restricting potato production in Pakistan during the spring crop (Abbas & Amrao, 2017).

Physiologically aged tubers result in higher canopy cover only in early stages. The photosynthetic rate depends on the leaf area, which itself vary with variety and growing conditions and. Thus, environment and varieties may differ extensively, and accordingly the leaf areas of potato varieties vary, although, canopy may be used as sign of a larger leaf area. An earlier Ethiopian study on potato reported that reproductive growth restricted vegetative enlargement and lowers tuber yield and quality. Canopy cover at 45 days was maximum in Kufri Bahar followed by Kufri Anand and Kufri

Pukhraj. The canopy cover (91%) was greatest in Kufri Bahar, which was non-significantly with Kufri Anand afterward Kufri Badshah and Kufri Sutlej. The least canopy cover (71.05%) was in Kufari Pukhaj (Bertschinger, 1992).

Variations in the height of the plant and the canopy cover may be due to differences in the behavioral patterns of the different plants. Decreases in optimum radiation, canopy photosynthesis and improved growth resulted in better indices such as vegetation time and greater plant growth. The breeding season of fruit tubers had a significant effect on soil cover at 30, 45, and 60 DAP. Plants are derived from the seeds of a more biological study than those of weeds. A large 47 grains yield high ground cover at any stage of growth with the exception of 60 DAP, where each difference is not significant. The health of the old tubers matured, as evidenced by the reduction of cover (Pourrahim *et al*., 2007).

DNA tests from the herbarium fruit have shown that from the beginning of the 18th century, Andean potatoes were commonly imported into Europe. This changed in the early 19th century, when almost all of the potatoes discussed belonged to the Chilean, since they were better adapted during the dry season and weather conditions of Northern Europe. In the 17th and 18th centuries, a series of devastating famines destroyed many empires of Europe (Smith *et al*., 2012). The introduction of potatoes into the daily diet of its inhabitants has halted almost all famine in Europe and the continent's population has grown exponentially, especially when guano has proven to be an effective crop fertilizer. Guano's trade has paved the way between Peru and northern Europe, and it is thought that *Phytophthora infestans* were transported by ship from South America to Central Europe in the mid-century of 19. Late disease has been identified as one of the worst disasters in plant history (Dhital *et al*., 2009). Ireland is the most affected country, with about one million starving to death in the years following the epidemic in late 1845. As a result of this disease, millions of people from Ireland and other countries in Europe moved to the next ten years of famine. Nevertheless, until the end of the 19th century, potatoes were considered a major crop (Marczewski *et al*., 2004).

Conclusion

The PLRV is a severe issue in potato-growing regions, and it should be appropriately handled as soon as possible, according to the review above. In a few years, it will be under control if it is not already. PLRV-resistant potato cultivars created through genetic modification. Environmentally friendly methods may help the environment while causing vectors to become more resilient.

Conflict of interest

The authors declared absence of conflict of interest.

References

Abbas, A., & Amrao, L. (2017). Potato virus Y: an evolving pathogen of potato worldwide. *Pakistan Journal of Phytopathology* **29**, 187-191. DOI: https://doi.org/10.33866/phytopathol.029.01.0310

Abbas, A., Arif, M., & Ali, M. (2016). A review paper on potato leaf roll virus (PLRV) of potato in Pakistan. *Asian J Agric Biol* **4**, 77-86.

Abbas, M. F., Hameed, S., Rauf, A., Nosheen, Q., Ghani, A., Qadir, A., & Zakia, S. (2012). Incidence of six viruses in potato growing areas of Pakistan. *Pak. J. Phytopathol* **24**, 44-47.

Abou-Jawdah, Y., Saad, A., & Sobh, H. (2001). Incidence of potato virus diseases and their significance for a seed certification program in Lebanon. *Incidence of potato virus diseases and their significance for a seed certification program in Lebanon*, 1000-1006.

Agindotan, B. O., Shiel, P. J., & Berger, P. H. (2007). Simultaneous detection of potato viruses, PLRV, PVA, PVX and PVY from dormant potato tubers by TaqMan® real-time RT-PCR. *Journal of virological methods* **142**, 1-9. DOI: https://doi.org/10.1016/j.jviromet.2006.12.012

Ahmadvand, R., Takács, A., Taller, J., Wolf, I., & Polgár, Z. (2012). Potato viruses and resistance genes in potato. *Acta Agronomica Hungarica* **60**, 283-298. DOI: https://doi.org/10.1556/AAgr.60.2012.3.10

Basky, Z. (2002). The relationship between aphid dynamics and two prominent potato viruses (PVY and PLRV) in seed potatoes in Hungary. *Crop Protection* **21**, 823-827. DOI: https://doi.org/10.1016/S0261-2194(02)00045-5

Bekele, B., Dickinson, M., Asefa, A., & Abate, E. (2011). Incidence of potato viruses and bacterial wilt disease in the west Amhara sub-region of Ethiopia. *Incidence of Potato Viruses and Bacterial Wilt Disease in the West Amhara Sub-Region of Ethiopia*, 149-157.

Bergervoet, J. H., Peters, J., van Beckhoven, J. R., van den Bovenkamp, G. W., Jacobson, J. W., & van der Wolf, J. M. (2008). Multiplex microsphere immuno-detection of potato virus Y, X and PLRV. *Journal of virological methods* **149**, 63-68. DOI: https://doi.org/10.1016/j.jviromet.2008.01.020

Bertschinger, L. (1992). *Modelling of potato virus pathosystems by means of quantitative epidemiology: An exemplary case based on*

virus degeneration studies in Peru ETH Zurich].
Bostan, H., Guclu, C., Ozturk, E., Ozdemir, I., & Ilbagi, H. (2006). Influence of aphids on the epidemiology of potato virus diseases (PVY, PVS and PLRV) in the high altitude areas of Turkey. *Pakistan Journal of Biological Sciences* **9**, 759-765. DOI: https://doi.org/10.3923/pjbs.2006.759.765
Cárdenas, H. M., Sánchez, P. G., & Montoya, M. M. (2017). Detection and sequencing of Potato virus Y (PVY) and Potato leafroll virus (PLRV) in a volunteer plant of Solanum tuberosum L. cv. Diacol-Capiro. *Acta Agronómica* **66**, 625-632. DOI: https://doi.org/10.15446/acag.v66n4.59753
Chatzivassiliou, E., Moschos, E., Gazi, S., Koutretsis, P., & Tsoukaki, M. (2008). Infection of potato crops and seeds with Potato virus Y and Potato leafroll virus in Greece. *Journal of Plant Pathology*, 253-261.
Chung, B. N., Canto, T., Tenllado, F., San Choi, K., Joa, J. H., Ahn, J. J., Kim, C. H., & Do, K. S. (2016). The effects of high temperature on infection by Potato virus Y, Potato virus A, and Potato leafroll virus. *The plant pathology journal* **32**, 321. DOI: https://doi.org/10.5423/PPJ.OA.12.2015.0259
Chung, B. N., Yoon, J.-Y., & Palukaitis, P. (2013). Engineered resistance in potato against potato leafroll virus, potato virus A and potato virus Y. *Virus genes* **47**, 86-92. DOI: https://doi.org/10.1007/s11262-013-0904-4
Davis, J., & Radcliffe, E. (2008). The importance of an invasive aphid species in vectoring a persistently transmitted potato virus: Aphis glycines is a vector of potato leafroll virus. *Plant Disease* **92**, 1515-1523. DOI: https://doi.org/10.1094/PDIS-92-11-1515
Dhital, S. P., Lim, H. T., & Manandhar, H. K. (2009). Elimination of potato viruses (PLRV and PVY) by cryopreservation of in vitro grown shoot tips of potato (Solanum tuberosum L.). *Horticulture Environment and Biotechnology* **50**, 233-239.
Dhital, S. P., Lim, H. T., & Sharma, B. P. (2008). Electrotherapy and chemotherapy for eliminating double-infected potato virus (PLRV and PVY) from in vitro plantlets of potato (Solanum tuberosum L.). *Horticulture Environment and Biotechnology* **49**, 52-57.
Djilani-Khouadja, F., Glais, L., Tribodet, M., Kerlan, C., & Fakhfakh, H. (2010). Incidence of potato viruses and characterisation of Potato virus Y variability in late season planted potato crops in Northern Tunisia. *European journal of plant pathology* **126**, 479-488. DOI: https://doi.org/10.1007/s10658-009-9554-8
Eigenbrode, S. D., Ding, H., Shiel, P., & Berger, P. H. (2002). Volatiles from potato plants infected with potato leafroll virus attract and arrest the virus vector, Myzus persicae (Homoptera: Aphididae). *Proceedings of the Royal Society of London. Series B: Biological Sciences* **269**, 455-460. DOI: https://doi.org/10.1098/rspb.2001.1909
Faccioli, G., & Colalongo, M. C. (2002). Eradication of potato virus Y and potato leafroll virus by chemotherapy of infected potato stem cuttings. *Phytopathologia Mediterranea* **41**, 76-78.
Fang, Y. L., Dhital, S. P., Li, K. H., Khu, D. M., Kim, H. Y., Song, Y. S., & Lim, H. T. (2005). Utilization of single nodal cuttings and therapies for eradicating double-infected potato virus (PLRV, PVY) from in vitro plantlets of potato (Solanum tuberosum). *Horticulture Environment and Biotechnology* **46**, 119-125.
Gul, Z., Khan, A. A., Khan, A. U., & Khan, Z. U. (2013). Incidence of potato viruses in different districts of Khyber Pakhtunkhawa, Pakistan. *International Journal of Phytopathology* **2**, 32-36. DOI: https://doi.org/10.33687/phytopath.002.01.0045
Kostiw, M. (2011). The occurrence of major potato viruses in Poland. *Journal of Plant Protection Research*. DOI: https://doi.org/10.2478/v10045-011-0035-7
Kotzampigikis, A., Hristova, D., & Tosheva-Terzieva, E. (2008). Distribution of potato leafroll virus (PLRV) and potato virus Y–(PVYN) in a field experiment. *Bulgarian Journal of Agricultural Science* **14**, 56-67.
Kushnarenko, S., Romadanova, N., Aralbayeva, M., Zholamanova, S., Alexandrova, A., & Karpova, O. (2017). Combined ribavirin treatment and cryotherapy for efficient Potato virus M and Potato virus S eradication in potato (Solanum tuberosum L.) in vitro shoots. *In Vitro Cellular & Developmental Biology-Plant* **53**, 425-432. DOI: https://doi.org/10.1007/s11627-017-9839-0
Li, J.-W., Wang, B., Song, X.-M., Wang, R.-R., Chen, L., Zhang, H., Zhang, Z.-B., & Wang, Q.-C. (2013). Potato leafroll virus (PLRV) and Potato virus Y (PVY) influence vegetative growth, physiological metabolism, and microtuber production of in vitro-grown shoots of potato (Solanum tuberosum L.). *Plant Cell, Tissue and Organ Culture*

*(PCTOC)***114**, 313-324. DOI: https://doi.org/10.1007/s11240-013-0327-x

Li, J.-W., Wang, M.-R., Chen, H.-Y., Zhao, L., Cui, Z.-H., Zhang, Z., Blystad, D.-R., & Wang, Q.-C. (2018). Long-term preservation of potato leafroll virus, potato virus S, and potato spindle tuber viroid in cryopreserved shoot tips. *Applied microbiology and biotechnology***102**, 10743-10754.

Marczewski, W., Flis, B., Syller, J., Strzelczyk-Żyta, D., Hennig, J., & Gebhardt, C. (2004). Two allelic or tightly linked genetic factors at the PLRV. 4 locus on potato chromosome XI control resistance to potato leafroll virus accumulation. *Theoretical and Applied Genetics***109**, 1604-1609. DOI: https://doi.org/10.1007/s00122-004-1780-z

Mortimer-Jones, S. M., Jones, M. G., Jones, R. A., Thomson, G., & Dwyer, G. I. (2009). A single tube, quantitative real-time RT-PCR assay that detects four potato viruses simultaneously. *Journal of virological methods***161**, 289-296. DOI: https://doi.org/10.1016/j.jviromet.2009.06.027

Nolte, P., Whitworth, J. L., Thornton, M. K., & McIntosh, C. S. (2004). Effect of seedborne Potato virus Y on performance of Russet Burbank, Russet Norkotah, and Shepody potato. *Plant Disease***88**, 248-252. DOI: https://doi.org/10.1094/PDIS.2004.88.3.248

Novy, R., Gillen, A., & Whitworth, J. (2007). Characterization of the expression and inheritance of potato leafroll virus (PLRV) and potato virus Y (PVY) resistance in three generations of germplasm derived from Solanum etuberosum. *Theoretical and Applied Genetics***114**, 1161-1172. DOI: https://doi.org/10.1007/s00122-007-0508-2

Novy, R., Nasruddin, A., Ragsdale, D., & Radcliffe, E. (2002). Genetic resistances to potato leafroll virus, potato virus Y, and green peach aphid in progeny ofSolanum etuberosum. *American Journal of Potato Research***79**, 9-18. DOI: https://doi.org/10.1007/BF02883518

Peiman, M., & Xie, C. (2006). Sensitive detection of potato viruses, PVX, PLRV and PVS, by RT-PCR in potato leaf and tuber. *Australasian Plant Disease Notes***1**, 41-46. DOI: https://doi.org/10.1071/DN06017

Pourrahim, R., Farzadfar, S., Golnaraghi, A., & Ahoonmanesh, A. (2007). Incidence and distribution of important viral pathogens in some Iranian potato fields. *Plant Disease***91**, 609-615. DOI: https://doi.org/10.1094/PDIS-91-5-0609

Robert, Y., & Bourdin, D. (2001). Aphid transmission of potato viruses. In *Virus and virus-like diseases of potatoes and production of seed-potatoes* (pp. 195-225). Springer. DOI: https://doi.org/10.1007/978-94-007-0842-6_20

Sertkaya, E., & Sertkaya, G. (2005). Aphid transmission of two important potato viruses, PVY and PLRV by Myzus persicae (Sulz.) and Aphis gossypii (Glov.) in Hatay Province of Turkey. *Pakistan Journal of Biological Sciences***8**, 1242-1246. DOI: https://doi.org/10.3923/pjbs.2005.1242.1246

Singh, R. P., Kurz, J., & Boiteau, G. (1996). Detection of stylet-borne and circulative potato viruses in aphids by duplex reverse transcription polymerase chain reaction. *Journal of virological methods***59**, 189-196. DOI: https://doi.org/10.1016/0166-0934(96)02043-5

Smith, E. A., DiTommaso, A., Fuchs, M., Shelton, A. M., & Nault, B. A. (2012). Abundance of weed hosts as potential sources of onion and potato viruses in western New York. *Crop Protection***37**, 91-96. DOI: https://doi.org/10.1016/j.cropro.2012.02.007

Srinivasan, R., & Alvarez, J. M. (2007). Effect of mixed viral infections (Potato virus Y–Potato leafroll virus) on biology and preference of vectors Myzus persicae and Macrosiphum euphorbiae (Hemiptera: Aphididae). *Journal of economic entomology***100**, 646-655. DOI: https://doi.org/10.1093/jee/100.3.646

Wang, B., Ma, Y., Zhang, Z., Wu, Z., Wu, Y., Wang, Q., & Li, M. (2011). Potato viruses in China. *Crop Protection***30**, 1117-1123. DOI: https://doi.org/10.1016/j.cropro.2011.04.001

Wang, Q., Liu, Y., Xie, Y., & You, M. (2006). Cryotherapy of potato shoot tips for efficient elimination of Potato leafroll virus (PLRV) and Potato virus Y (PVY). *Potato Research***49**, 119-129. DOI: https://doi.org/10.1007/s11540-006-9011-4

Were, H., Kabira, J., Kinyua, Z., Olubayo, F., Karinga, J., Aura, J., Lees, A., Cowan, G., & Torrance, L. (2013). Occurrence and distribution of potato pests and diseases in Kenya. *Potato Research***56**, 325-342. DOI: https://doi.org/10.1007/s11540-013-9246-9

Yi, J.-Y., Lee, G.-A., Jeong, J.-W., Lee, S.-Y., & Lee, Y.-G. (2014). Eliminating Potato Virus Y (PVY) and Potato Leaf Roll Virus (PLRV) using cryotherapy of in vitro-grown potato shoot tips. *Korean Journal of Crop Science***59**, 498-504.

DOI: https://doi.org/10.7740/kjcs.2014.59.4.498

Zhang, W., Zhang, Z., Fan, G., Gao, Y., Wen, J., Bai, Y., Qiu, C., Zhang, S., Shen, Y., & Meng, X. (2017). Development and application of a universal and simplified multiplex RT-PCR assay to detect five potato viruses. *Journal of general plant pathology* **83**, 33-45. DOI: https://doi.org/10.1007/s10327-016-0688-1

Zhu, M., Radcliffe, E. B., Ragsdale, D. W., MacRae, I. V., & Seeley, M. W. (2006). Low-level jet streams associated with spring aphid migration and current season spread of potato viruses in the US northern Great Plains. *Agricultural and Forest Meteorology* **138**, 192-202. DOI: https://doi.org/10.1016/j.agrformet.2006.05.001