Review Article

Plant Diseases and Pests, Growing Threats to Food Security of Gilgit-Baltistan, Pakistan

Aqleem Abbas[1], Mustansar Mubeen[2], Waqar Younus[1], Qaiser Shakeel[3], Yasir Iftikhar[2]*, Sonum Bashir[2], Muhammad Ahmad Zeshan[2] and Azhar Hussain[1]

[1]Department of Agriculture and Food Technology, Karakoram International University, Gilgit, Pakistan; [2]Department of Plant Pathology, College of Agriculture, University of Sargodha, Sargodha 40100, Pakistan; [3]Cholistan Institute of Desert Studies, The Islamia University of Bahawalpur, Bahawalpur, Pakistan.

Abstract | The Gilgit-Baltistan (GB) region of Pakistan was free from plant diseases and pests. However, plant diseases and pests intensities are increasing and threatening the food security of GB. These plant diseases and pests seem to be exacerbated by climate change and transmitted to GB from other regions with food supplies and spillover. In addition, the evolution of new pathogen and pest strains causes catastrophes to GB's cereal and horticultural Crops. Moreover, Traditional plant varieties that resist disease and pests have been supplanted with fragile but high-yielding cultivars. As a result, diseases like rust, smut, black scurf, early blight, late blight, potato leaf roll virus, potato virus Y, grey mold, mildew, crown gall disease, gummosis disease, and nematodes and pests such as insect pests, i.e., fruit fly, armyworms, apple wooly aphids, aphids, mealy bug, scales and whiteflies, and parasitic weeds are considerably affecting GB crops. These diseases and pests can jeopardize GB's food supply if not monitored regularly. The consequences of these biotic agents range from minor symptoms to catastrophic events that destroy whole fields. Plant protection units are needed to tackle these challenges to prevent future outbreaks. Herein, we describe significant diseases and pests that are catastrophic to GB's crops in the future. In addition, this review shows how diseases and pests impact the yields of GB's crops.

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***Correspondence** | Yasir Iftikhar, Department of Plant Pathology, College of Agriculture, University of Sargodha, Sargodha 40100, Pakistan; **Email:** yasir.iftikhar@uos.edu.pk
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Introduction

Gilgit-Baltistan (GB), with a total area of 72,971 km^2 (28,174 sq. mi), is the northernmost territory administered by Pakistan (Hussain *et al.*, 2021). GB is one of the world's most beautiful areas, with fifty of the world's highest mountains and three of the world's longest glaciers. It is linked to the Xinjiang region of China to the east and northeast, Khyber Pakhtunkhwa (KPK) to the west, Azad Kashmir to the south, and Afghanistan's Wakhan Corridor to the north via the Karakorum Highway (KKH) (Butz

and Cook, 2011). Gilgit Baltistan is divided into three divisions: Diamer, Gilgit, and Baltistan, each of which is further divided into districts: Baltistan's Skardu, Roundu, Kharmang, Shigar, and Ghanche, and Gilgit's Astore, Ghizer, Hunza, Nagar, and Gupis-Yasin (Butz and Cook, 2011) (Figure 1). The agricultural industry employed most of the GB people in 2000, but services have lately eclipsed agriculture as the primary source of income.

Figure 1: *Districts of Gilgit-Baltistan.*

The most frequent fruits include cherry, apricots, apple, pear, peach, quince, pomegranates, and grapes (Ali *et al.*, 2010, 2014; Abbas *et al.*, 2018). Potatoes and tomatoes are one of the primary revenue sources for GB's farming sector (Hussain *et al.*, 2017a). The main cereal crops are wheat and maize. GB's harsh winters, mild springs, and hot, dry summers make the region ideal for growing fruits, vegetables, and grains. Besides food crops for humans, grasses are also essential in the perspective of cattle feeds (Joshi *et al.*, 2013). The environment of GB is the most vulnerable, and the effects of climate change are more severe and catastrophic. Temperature rises and heavy rains linked to global climate change have led to severe diseases and insect infestations, resulting in food insecurity for the people of GB. The monsoon from the east has a minor impact on GB's climate, mainly driven by winds from the west (Majeed and Muhammad, 2018). The average annual rainfall is 140.73 mm, with an average maximum of 23.66 mm in May and June and an average low of 2.26 mm in January and 3.0 mm in November. Major climatic characteristics include hot summers, frigid winters, and significant seasonal variations. The average monthly maximum temperature in July and August is 25.19°C, while the average monthly minimum temperature in December and January is 4°C (Joshi *et al.*, 2013). Plant diseases and pests were absent in the region due to its unique geographic and climatic characteristics.

However, replacing disease and pests resistant traditional varieties with high-yielding but susceptible varieties reduced the genetic diversity and enhanced the plant diseases and pest severities. For example, before the 2000s, wheat was growing as a significant crop in GB. However, its production is limited by severe rust and smut diseases. As a result, farmers shifted their lands typically reserved for wheat to potatoes amid the rust and smut diseases. Plant diseases i.e., early blight and late blight and potato crop, grey molds, mildews, gummosis crown gall disease, and nematodes, are becoming severe dangers to GB's crops (Ali *et al.*, 2010; Abbas *et al.*, 2018, 2020). Besides these diseases, pests such as fruit flies, armyworms, apple wooly aphids, aphids, mealy bugs, scales and whiteflies also emerge as threats to GB's crops (Abbas *et al.*, 2015). Gummosis has severely infected apricots, almonds, plums, pears, and peaches. Grey mold and mildew infections wreak havoc on grapes. black scurf, early blight and late blight diseases wreak havoc on potato output, while powdery mildews wreak havoc on cucumbers, peppers, and crucifers (Hussain *et al.*, 2017). Fruit flies, aphids, scales and mealy bugs are causing considerable losses to the quality and quantity of fruit trees. In addition, parasitic weeds including *Orobanche* spp. parasitize roots of many plants whereas *Cuscuta* spp. parasitizing shoots of various crops. The above-mentioned plant diseases and pests must be managed immediately to ensure food production and the long-term viability of the GB natural ecosystems. To develop an effective plant disease management strategy, it is necessary to understand the biology of new plant diseases and to connect and interact with stakeholders and policymakers. This study aims to gather and explain GB crops' most common plant diseases and pests. This review will give a quick rundown of essential new plant diseases, problems and their impact on producing economically essential crops, vegetables, and fruit trees.

Early blight

Potato (*Solanum tuberosum* L) is a very valued, healthy food that is also a key cash crop in Gilgit-Baltistan (GB). It is the world's most commonly cultivated food and cash crop, with significant nutritional and economic value. It generates more calories per hectare than grains like rice and wheat (Akhtar *et al.*, 2019). It belongs to the *Solanaceae* family, which includes chili, eggplant, tobacco, and tomato (Akhtar *et al.*, 2019). However, it is said to have originated in the Andes and been brought to the subcontinent

by Portuguese traders. It has now become a staple in nearly every meal in Pakistan. Pakistan's peculiar climate makes it ideal for potato cultivation (Abbas *et al.*, 2018). Potato output in GB has recently grown due to expanded land and new cultivars. Potatoes are a cash crop; therefore, they have become a significant source of revenue for farmers. In 2017, the potato crop produced around 20 bags (70-80 kg/bag)/Kanal. However, because the territory is very hilly and crops ripe at different times depending on the elevation of potato production areas, calculating GB's annual potato production is challenging. The early blight disease has recently invaded the potato crops of the Normal Valley in GB (Figure 2). Early blight is a significant foliar disease in GB (Akhtar *et al.*, 2019) due to its survival in many environmental conditions. Early blight has been a danger to potato production in GB. The most significant occurrences have been documented in the country's Nomal Valley (Abbas, 2017c). Normal Valley is split into six Mohallahs or main sections. Jigot, Batot, Majini, Das, Sigal and Ishpis are the Mohallahs. During June and July 2016, a survey was conducted in five randomly selected fields of each Mohallah in Valley Nomal. Five potato plants were chosen at random from each field and inspected for typical early blight signs. Tubers were also checked for early blight signs during the harvesting stage. The occurrence and severity of the disease was noted. Potato fields in Jigot had the greatest percent disease severity (66.4%), followed by potato fields in Sigel (63.2%), Majini (42%), and Batot (36%). Meanwhile, the lowest percent disease severity in Das potato crops was reported (12%). Early blight is a significant danger to potato output in the Nomal Valley of GB, according to the findings of this study (Abbas, 2017c). Within a single cropping season, this polycyclic disease can produce several disease outbreaks. It creates a large number of secondary inoculums and is challenging to manage. Early blight is recorded from GB and reported from all of Pakistan's potato-growing regions, and it is one of the most common foliar diseases in areas with favorable weather. Early blight disease was recognized to be caused by two *Alternaria* spp. (*A. solani* and *A. alternata*) (Akhtar *et al.*, 2019). The circumstances favor early blight disease in GB's irrigated potato fields because of the dry weather and low organic matter content. As previously said, early blight causes economic losses in potato output; thus, planning and implementing an effective management strategy is critical. Multiple *Alternaria* species genomes have recently been sequenced, and research like this give vital information on the genes involved in disease transmission. To summarize, genome assembly is a critical step in gaining a better knowledge of the pathogenicity of *Alternaria* spp. (Akhtar *et al.*, 2019).

Figure 2: *Major diseases and pests of GB. PVY (A), PLRV (B), Late Blight (C,D), Smut of grass (E), Smut of maize crop (F), Early Blight of tomatoes (G,H), Powdery mildew of cucumbers (I), Apples are infested by a pest (J), Fruit fly infestation of peaches (K) and Cuscuta spp. parasitizing potatoes (L).*

Late blight disease

Plants that were formerly disease-resistant have been replaced with high-yielding but vulnerable types. Consequently, serious risks in the form of severe diseases have emerged. Late blight is the most serious disease that damages potatoes (Subhani *et al.*, 2015) (Figure 2). The late blight is caused by *Phytophthora infestans* which are restricting potato output not just in GB but also globally (Kieu *et al.*, 2021). Because of its expanding spreading potential, it is currently the most devastating disease in GB. In the 1990s, potato varieties from Pakistan's Kalam and Malam Jaba valleys were introduced to GB. Since then, late blight has been discovered in all of GB's potato-growing areas, particularly in the higher valleys such as the Nalter, Nomal, and Dayetar Valleys. Because the temperature in GB is colder, pathogens thrive there. The pathogen can adapt to a wide range of environmental circumstances. Both potato tubers and foliage are severely affected by the disease. GB's temperate and other climatic factors are conducive to the fast spread of many disease (Raza *et al.*, 2021). The recent irregular and heavy rainfall have also aided the disease's spread. The pathogen has been found to infect at all developmental stages. Moreover, severely infect stems, tubers, and leaves. On the edges and underside of the leaves, there is a whitish cottony

growth visible, whilst the top surface of the leaves is covered in brownish-green lesions. On the petioles and stems, however, lesions that were dark brown or black were visible. It was found that the potato tubers were decomposing. Integrated disease management (IDM) can be used to manage potato late blight, however the best way to combat the disease is to create resistant cultivars. However, in GB, there is no equivalent Plant Pathology and Plant Breeding institute for testing potato germplasm. All commercial cultivar is now vulnerable to late blight. New cultivars have been produced in different Pakistani provinces; however, they must be tested for the existence of late blight disease-resistant genes. Fungicides may help decrease the frequency of late blight; however, farmers in GB do not have access to them (Raza *et al*., 2021). Furthermore, using fungicides can potentially diminish the variety of other species in the area and contaminate the environment. Fry (2020) presented compelling reasons for the persistence of late blight pathogens (Fry, 2020). *P. infestans* is the most infamous plant pathogen of the potato crop due to the emergence of novel late blight disease strains with increased virulence and emergence in new locations with high intensity. The authors also presented up-to-date information on late blight disease population biology and molecular genetic analyses (Fry, 2020).

Grey mold disease

The people's economy relies heavily on fruits (Abbas, 2017b). In GB, there are several regionally produced grape varieties with distinct characteristics. Grape infections have recently caused issues for viticulturists of GB. The increased rainfall in recent years, linked to climate change, has aided the spread of disease. The grey mold fungus (*Botrytis cinerea*), a necrotrophic fungus, is one of the diseases that cause significant losses in ripening grapes in GB (Abbas, 2017b).

Other parts of Pakistan, such as Lahore, have been found to have over 40% of grapefruits infected with grey mold or *Botrytis* bunch rot disease (Javed *et al*., 2017). The fungus has an asexual form, and the sexual form is seldom seen. Grey mold fungus infects grape berries, reducing productivity and degrading fruit quality. The fungus commonly causes grapes to become so damaged that they are unsuitable for consumption. Recent spring rains have resulted in wet conditions that induce grape branch blight before fruit ripening. On the diseased plant portions, soft brown tissues form. The infection has spread to the leaf axils, causing the shoots to droop or collapse. Depending on the cultivar, the diseased berries turn brownish or reddish. Epidermal cracks arise where the fungus's mycelium and spores grow because of the moderate temperature and light breeze. As a result, the grape cluster seemed to be uniformly gray and velvety in texture. At the harvesting stage, the fungus produces hard, resistant structures called *sclerotia* on the diseased grape berries. These berries drop on the ground or left handing on vines and become a source of infection in the next season. In the following season, these sclerotia germinate and generate spores carried by winds, splashing rain, or irrigation water. Infection by this spore is possible if free water and a reasonable temperature are accessible. In the spring, flowers become infected and spores through the pedicel's tip enter the stigma. The fungus then becomes dormant, waiting for the sugar content in the infected fruit to rise later in the season. The fungus then begins to infect the berries and quickly spreads throughout them. As the disease spreads, the berries split and break, allowing pathogens to spread to neighboring berries. When the relative humidity is quite high, there is a lot of free moisture present, and the temperature is moderate, late infections become more severe. When insects and birds injure the berries, they get diseased. Because there is a lot of water and nutrients available when the fruit starts to ripen, the fungus can spread quickly and produce a serious disease. Introducing resistant cultivars, cultural techniques, and environmentally friendly biocontrol agents can help manage this disease (Javed *et al*., 2017). It is challenging to manage grey mold disease because it contains a variety of mechanisms of infections. It also has a wide range of hosts and can persist for a very long time as mycelia, conidia, and *sclerotia*. Rainfall patterns are unpredictable and variable, making it challenging to handle grape diseases in a timely manner. Furthermore, there are no cultivars that can be used to reduce the financial losses brought on by the grey mold disease. Fungicides are quite expensive and not eco-friendly. Heavy post-harvest costs are also caused by a lack of marketing and storage facilities.

Mildew diseases

Powdery mildews: Powdery mildews have widely infected vegetables, ornamentals and fruit trees of GB (Figure 2). Among the vegetables. In Gilgit Baltistan (GB), Pakistan, cucumbers are the most significant vine crop and are widely planted (Khan and Khan, 1999).

The research was carried out in the cucumber fields of village Nomal (Abbas, 2017a). Cucumber powdery mildews (CPM) disease found in cucumbers. Five fields were chosen randomly in each section of village Nomal. Twenty plants were chosen at random from each field and tested for the presence of powdery mildews. The severity of CPM and the disease incidence (%) were reported. The cucumber fields in section Majini had the greatest percent disease incidence of CPM, with a value of 60%, followed by sections i.e., Batot (58%), Jigot (49%) and Das (43%). However, Sigal (37%) section had the lowest percent disease incidence of CPM. Cucumber powdery mildew, caused by fungal pathogens i.e., *Erysiphe cichoracearum* and *Sphaerotheca fuliginea*, is a worldwide problem of cucurbits that is regarded as one of the most damaging diseases due to its increased prevalence and incidence, resulting in a loss in fruit production. In Mexico, the fungus *Leveillula taurica* has recently produced powdery mildew on cucumbers (Beltrán-Peña *et al.*, 2018).

Downy mildews

Downy mildew is a highly destructive disease of grapes in all grape-growing areas of Pakistan, including GB (Farouk *et al.*, 2017). In the spring and summer seasons, the temperature of GB increases above 15°C and maximum rainfall has also been recorded in these two seasons. Therefore, during this two-season downy mildew emerges as a severe disease of grapes. Symptoms are usually observed on the leaves as yellow circular spots and these spots are surrounded by halos of brownish-yellowish or reddish-yellowish colors. In summer, whitish fungal growth appeared on the underside of the grape leaves when the temperature became warm and humid. The disease spread to fruit bunches and withered them. The fruits become brownish and finally die. *Plasmopara viticola* is known as the causal agent of downy mildew of grapes. In GB, farmers normally used cultural practices such as pruning to reduce the density to properly aerate the fruits and leaves to avoid high humidity that can provide favorable conditions for the downy mildew to infect grapes. Some farmers broadcast ashes to the leaves and fruits and around the crown of grapefruits. However, due to the lack of availability of resistant grapes germplasm, the disease is continuously devastating the grapes of GB.

Gummosis disease

Fruit trees of GB, such as apricots, cherries, almonds, plums and peaches, are severely infected by gummosis. In Pakistan, GB is a significant apricot-producing region. According to one estimate, the entire fruit yield is around 1,70,680 tons/year (Ma *et al.*, 2021). The differences have increased due to better plants' regular grafting and seed planting. On the other hand, fruit trees are susceptible to diseases due to variable climatic and soil conditions. Heavy summer floods caused by glacier melting alter soil conditions and disrupt the usual gaseous exchange between fruit plants and their surroundings.

Furthermore, it promotes tree weakening and sedimentation. Floods significantly impact fruit plants' roots, root collar, and lower stem. Fruit trees are more susceptible to pests and diseases due to the damage in these areas. Furthermore, strong winds in the late fall inflict significant damage, making fruit trees susceptible to disease. Cracks in the main trunk, branches, and twigs of fruit trees are also caused by severe cold, snow, and ice. Diseases can enter through these gaps. Fruit trees production capacity is constantly being reduced by these diseases, which hurts fruit quality.

Furthermore, the introduction of high-yielding cultivars is gradually displacing native types. Though these cultivars are high producing, they are susceptible to disease in various climatic situations. The output of apricots, cherries, almonds, plums, and peaches has decreased significantly as a result of illnesses such gummosis (Mancero-Castillo *et al.*, 2018). Gummosis disease causal agent has yet to be identified in GB (Abbas, 2018a). Diseases, pests, and other abiotic variables like strong winds and snow are all linked to gummosis. Gummosis can also be caused by unsterilized pruning and grafting instruments. According to some experts, gummosis is a non-specific defense response of trees to infections and other differential stressors (Ezra *et al.*, 2017). The disease severely damaged thousands of apricots, cherry, almond, peach, and plum trees in Gilgit-Baltistan (GB). Gums have leaked through the main stem's barks, twigs, branches, and even on the fruits, indicating the presence of the illness. Cankers form along the main trunks, branches, and twigs of fruit trees as they mature (Ma *et al.*, 2021). Gummosis illness has a long history of being linked to fruit trees. As a result, gummosis is regarded a persistent disease of fruit trees in GB. Gum exudates are commonly used as food by the locals. Gums have pharmacological, functional, antioxidant, and antibacterial effects

(Mancero-Castillo *et al*., 2018). The fruit trees were surveyed in June 2016 and the first data on gummosis disease was gathered.

Gum deposits were yellowish in color, translucent, and shaped irregularly. The gum deposits had a diameter of 4-5 cm around the trunk and branch lenticels. The gum deposits on the twigs, on the other hand, were 1-2 cm in diameter. Gummosis is rapidly spreading over the GB's fruit-growing regions. There isn't a single fruit tree kind that is resistant to gummosis. As a result, prompt care for this condition is critical. On wet days, peach, apricots, almonds, and plums become prolific gum producers, followed by peach, apricots, almonds, and plums. The disease infects fruit trees by sores or lenticels on branches, twigs, and main trunks. Plant diseases enter through lenticels, breathing holes in twigs, branches, and the main trunk. Small, depressed, and discolored patches form around the lenticels and injuries. After that, the region becomes black and cracked, with sticky exudation that is yellowish or white. In young fruit trees, yellowing and drooping leaves are frequent signs. In fruit tree orchards, the disease has a substantial economic impact. Furthermore, the disease is decreasing the lifetime of fruit trees and generating significant losses in GB.

Crown gall disease

Fruit diseases emerge when certain environmental factors, such as temperature, rain, and relative humidity, are met. Any illness's incidence and severity determine how far each climatic variable deviates from the ideal range for disease development (Ali *et al*., 2010). As a result, recent heavy rains and high temperatures may be conducive to the beginning and development of numerous bacterial, fungal, and viral diseases of fruits in GB. Crown gall is a bacterial disease that has killed mulberry, apple, peach, quince, and apricot trees in GB. GB is the largest apricot-producing region, and apricot trees are severely infected by crown gall disease. Apricots are grown on 6170 hectares in GB, yielding 60305 tons of fruit yearly. Apricot production is well-known in the Nagar, Hunza, and Nomal valleys (Ali *et al*., 2010). The apricot varieties grown in Baltistan include Halmand, Wahphochuli, Lonakpochuli, Sherakarpochuli Shakhanda, Margulam, Karpochuli, Ambah, Staachuli, Khochuli, and Brochuli. The Gilgit Division produces a variety of apricots, including Dugli, Neeli, Bedeiri, Chalpachu, Loli, Frugui, Khormagui, and Alishah Kakas. Crown gall disease, caused by *Agrobacterium tumefaciens*, has recently become a significant danger to apricot in GB. Crown gall disease was discovered on apple, apricot, and cherry trees in the Nagar and Nomal valleys of GB in November 2008. From November 2008 to February 2008, these fruit trees were studied to establish the frequency, prevalence, and severity degree of Crown gall in the Districts Gilgit and Nagar. In Nomal valley, the disease incidence and severity of crown gall were around 99% in cherry trees and 97% in apple trees. In the Nagar valley, illness incidence and severity of crown gall were 97% in cherries and 98% in apples. Surprisingly, these Valley's apricots have reported no cases of crown gall disease (Ali *et al*., 2010). Crown gall symptoms were discovered on apricot trees in the Nagar and Nomal valleys of GB in the spring of 2016. Abnormal galls and tumors were discovered on the apricot trees' roots and crowns. Secondary wood rots were also discovered in several of the diseased apricot trees. The symptoms were identical to those previously reported (Ali *et al*., 2010). Furthermore, the pathogen must be characterized visually (colony color, colony form), biochemically (fatty acid analysis, oxidase and catalase activity), molecularly, and, most significantly, by next-generation sequencing for additional confirmation (NGS). Crown gall bacteria are mostly found in the gall tissues of the infected trees. Injuries might allow germs to infiltrate apricot plants. To our understanding, incorrect apricot cuts, grafting, and plucking using unsterile items and unsanitary procedures may have resulted in injuries, which then became the pathogen's entrance site. Because apricot cuttings were recently imported, the crown gall bacteria may have arrived in GB via these cuttings. The apricot farmers in GB must plant certified, disease-free apricot trees. They prevent the spread of crown gall disease and avoid critical injuries. Biological control agents such as *Agrobacterium radiobacter* strain K84 can also be used to manage the disease, however BCAs are presently unavailable to GB apricot farmers. Antibiotics are another option for treating crown gall disease. Most *Agrobacterium tumefaciens* strains isolated from cherry and apple and trees in Nomal and Nagar valley were resistant to antibiotics such as Lincomycin, Amoxycillin, Ampicillin, and Cloxacillin. In contrast, Cephradine, Tetracycline, and Dioxycycline were susceptible (Ejaz *et al*., 2020). Furthermore, because these antibiotics have medicinal and veterinary applications and are neither cost-effective or environmentally friendly, using them to treat crown gall disease is not a good idea.

Black scurf disease

Black scurf (*Rhizoctonia solani*) is a notorious disease of potatoes. Kuhn (1858) was the first to describe its occurrence. It is isolated from all of potato-growing GB's regions. Black scurf is a widespread fungal disease in Pakistan that is a severe concern in all potato-growing regions. The disease is spread via soil and seed (Hussain *et al*., 2017b). On potato tubers, the pathogen develops resistant *sclerotia* structures ranging in size from 1-10mm. *Sclerotia* cling to potato tubers and are challenging to wash away (Takooree *et al*., 2021). The disease causes potato tubers to shrink in size. Other signs of this illness include creaking, deformation, and pitting, resulting in poor potato tuber quality. This disease can be found in potato-growing regions (Takooree *et al*., 2021). Black scurf isn't just a problem in GB; it's also been recorded in other parts of Pakistan, particularly the northern parts of Khyber Pakhtunkhwa province and a few portions of Punjab province. For the planning and development of effective disease control programs, detailed information on the geographical spread of a crop disease is essential. In 2012-13, the frequency, prevalence, and severity of black scurf illness were assessed throughout the potato harvesting stage. A total of four GB valleys (Bagrote, Harmoush, Shigar, and Hoper) were chosen for this purpose, with four valleys from each Valley. Three to seven fields were chosen at random in each hamlet. Black scurf disease signs were apparent on the potato tubers; therefore, they were sampled. Then, in each of the four valleys, the total prevalence range (25-75%), incidence (5.55-23.89%), and severity (1.67-6.55%) were documented. Hussain et al. (2017a) use GIS technology to demonstrate better topics for studying black scurf illness (Hussain *et al*., 2017b). The black scurf pathogen is a necrotrophic basidiomycete fungus with fourteen reproductively incompatible anastomosis groups that live in the soil (AGs). Through stem canker and black scurf in potatoes, the disease causes quantitative and qualitative yield reductions (Takooree *et al*., 2021).

Smut and rust diseases

The production of forage ranges from 500 to 1,500 kg ha^{-1} in GB. The commonly found grasses in GB are; *Chrysopogon* spp., *Cymbopogon* spp., *Dichanthium annulatum*, *Pennisetum orientale*, *Aristida* spp., *Oryzopsis* spp., *Dactylis glomerata*, *Poa* spp., *Bromus inermis*, *Agrostis* spp., *Rottboellia exaltata*, *Phacelurus speciosus* and *Eragraostis* spp. (Salim *et al*., 2019). In 2000, cereals such as maize and wheat were the major food crop of GB. However, rust and smut diseases have devasted wheat crop, less production of wheat due to these diseases diverted farmers to potato cultivation (Figure 2). Potatoes are nowadays a major cash crop and widely grown in GB. Smut diseases continuously threaten the grasses and maize crop. In August 2018, smut disease was detected in the grasses of Nomal and Nalter Valleys of GB (Abbas, 2018b). The spikelets of grasses were swollen and filled with blackish and greyish powdery masse, leaves were distorted and stunted, and production was substantially reduced. In addition, the infected grasses occurred in patches alongside healthy grasses throughout the growing fields.

Shot hole disease

Shot hole disease is also a severe fungal disease of fruit trees in Pakistan, India and China (Nabi *et al*., 2018; Ye *et al*., 2020). The causal agents of shot hole disease include *Wilsonomyces carpophilus, Clasterosporium carpophilum* and *Stigmina carpophila*. GB's fruits are not free from the shot hole disease. The disease has severely infected GB's almonds, apricot, nectarine, peach, prune, and cherry trees. Symptoms include small leaf holes, lumpy fruit areas, and concentric lesions on branches. The fruits, buds and stems are also severely infected. However, prominent symptoms are found on the leaves. Initially, small reddish or purplish-brown spots with light green or yellow rings are formed. As the disease progresses, the spots become larger and then leaves dry up and fall away. Significant infections reduce the amount of photosynthesis and weaken the plant and reduce fruit production. Tiny purple spots on fruits are formed, turning to grey-white lesions. Finally, gummosis may occur on the fruits and stems as well. Concentric lesions are also included on the branches. The lesions surround twigs and kill them.

Fruit fly

High quality and juicy contents make GB's fruit more popular in Pakistan. However, these fruits are divested by various species of fruit fly (Hussain *et al*., 2019) (Figure 2). The fruit fly is one of the major pests that devastated GB's fruits. Fruit fly causes severe losses to fruit quality and juicy contents. Recently it has become a severe pest of peaches in GB. A survey recorded peach fruit fly infestation in Nomal Valley, GB of Pakistan. The rate of damaged fruits varied from 89-59% in Nomal valley. Though the study provides preliminary information, however, there is urgent to manage this pest sustainably; otherwise, tons of fruits

of GB will be wasted (Hussain *et al*., 2019).

Aphids, mealybugs, scales, whiteflies, apple wooly aphids, armyworms

GB's fruit trees are also severely attacked by several aphid species, mealy bugs, whiteflies, armyworms and scales (no data available). Among the aphid species, the green peach aphid is causing substantial loss to vegetables including potatoes and tomatoes, ornamental plants such as roses, crops such as mustard species and also the fruit trees (Abbas *et al*., 2015). Mealybugs and scales have devastated GB fruit trees. Common concerns with almonds, persimmon, apples, grapes, pears, pomegranate, plum and peaches in GB include mealybugs, which are little, soft, wax-covered insects. Mealybugs feed on plant sap and may coat plants with a sticky honeydew that they create. Whiteflies seem to severely infest pomegranates as well as other fruits. Infestation of these pests not only reduce quality but also cause dwarfism and curling of leaves. In addition, severely reducing the growth rate of various fruit trees. These pests are vectors of various diseases especially viral diseases. Woolly apple aphids feed on the sap of apple trees and may cause damage to the tree's roots, trunk, branches, and even its fruit. These aphids, which feed on bark, are totally coated in white, wool-like waxy compounds. During the winter, this aphid may be seen in large colonies on the tree's roots as well as its aerial parts. During the summer and autumn, the nymphs will move either upwards or downwards the trunk of afflicted trees. In recent years, armyworms have rampaged many, GB crops including wheat, oats, maize, clovers, berseem and beans. To tackle these pests there is a need to promote natural enemies.

Nematodes

Nematodes are thread-like roundworms that are inhabitants of soil and water (Montarry *et al*., 2021). Various nematodes feed on fungi, bacteria, protozoans, other nematodes, and plants. Some nematodes parasitize insects, humans, and animals, while some are free-living (Shoaib *et al*., 2020). Among these nematodes, plant-parasitic nematodes are ubiquitous in agricultural soils including soil of GB. Most plant-parasitic nematodes pierced and killed root cells with a needle-like structure known as stylets. Most plant-parasitic nematodes feed by piercing and killing root cells with needle-like structures called stylets. Among these plant-parasitic nematodes, root-knot nematode (RKN) and soybean cyst nematode (SCN) are likely prevalent in GB. As potatoes are a major cash crop, these nematodes are severe pests of potatoes. Symptoms include impaired root growth and functions and stem and root rots. In addition, yellowing of leaves, stunting and wilting of potato plants, and yield decline are noted in some potato fields.

Plant-parasitic weeds

In GB, two weedy parasites (pest) such as *Orobanche* spp. and *Cuscuta* spp. (*C. campestris*) (Sun *et al*., 2018) considerably affecting the roots and shoots of various plant species of GB (Figure 2). The seeds of *Orobanche* survive in the soil for a long time even in the harsh environmental condition of GB until favourable conditions including suitable temperatures and humidity, and a chemical stimulus from host roots available for their germination. In favourable conditions, the seed germinates, developing a haustorium that penetrates host root tissues, enters the vascular system and sucks water and nutrients the other parasitic weed *Cuscuta* spp. Germinate independently from the nearby host. It climbs around the shoots and coils upon germination, sticks to the stem, and develops haustorium. Finally, it reaches to host conductive tissues and obtains its nutritional needs from the host. Both these parasitic weeds have destroyed legumes and vegetables notably potatoes and legumes of GB.

Plant viruses

Viral diseases play a major role in reducing the yield of GB fruit trees, crops and vegetables (Abbas *et al*., 2020) (Figure 2). Symptoms such as yellowing, mottling, mosaic, cupping, and curling of potatoes, peppers, and tomato leaves have been observed. Among the viral diseases, notably potato leaf roll virus (PLRV), potato virus X (PVX) and potato virus Y (PVY) may be prevalent in GB (Abbas *et al*., 2020). These viruses have been introduced into GB via seeds and potato tubers. The tubers of potatoes imported from other Pakistani provinces have continued to introduce viruses.

Furthermore, the insect vectors of these viruses, such as aphids and whiteflies, have recently increased. These plant viruses have considerable effects on potatoes, tomatoes and peppers ranging from mere curling and chlorosis of leaves to the demise of these plants from the fields. There are no effective regulatory measures in place to stop the spread of plant viruses. Moreover,

there is no well-established virus detection laboratory in GB, so their valid adequate identification and estimation of yield losses remain challenging.

Conclusions and Recommendations

Since the dawn of time, plant diseases and pests have threatened food availability, and their impact on human history cannot be ignored. Due to the development of quick transportation techniques and unrestricted travel by visitors, exotic plant diseases and pests that did not previously exist in Great Britain have been introduced. It has led to an increase in the spread of plant pests and diseases in GB in recent years. For instance, armyworms recently caused significant infestations of maize, wheat, oat, berseem, clovers, and beans. Gummosis and crown galls, on the other hand, have become epidemics that affect apples, plums, cherries, apricots, and almonds. For many years, parasitic plants like *Cuscuta* have ravaged berseem and clovers. Numerous horticultural and vegetable crops suffer greatly from the diseases grey mould, mildew, early blight, late blight, and black scurf. The fruit fly, white fly, aphids, scales and mealy bugs are a continuous threat to horticultural crops. Moreover, the effects of plant diseases and pests have been amplified as a consequence of global climate change; as a result, these diseases and pests have emerged as a more significant danger to horticultural and cereal crops and the food security of GB. As a result, frequent monitoring and identification of these diseases and pests are necessary for sustainable agriculture. In addition, thorough sampling utilizing molecular techniques such as PCRs is critical for disease and pest detection. The severity of these diseases and pests can also be reduced while crop yield is increased by using cultural practices, biopesticides, disease-specific chemical treatments, and biocontrol agents. In addition, contemporary techniques such as disease surveillance and better detection technologies such as sensors, predictive modeling, and data analytics must be introduced to avert future plant disease outbreaks in GB. In addition, plant protection and plant pathology institutions should be established in GB to combat these diseases and pests.

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Novelty Statement

The current paper summarizes updated knowledge regarding Plant Diseases and Pests of GB, Pakistan, which help in future to developed the management plans.

Author's Contribution

Aqleem Abbas: Prepared the outline, wrote introduction and figure preparations.
Mustansar Mubeen: Wrote Pests and Plant viruses.
Waqar Younus: Collection of literature and software.
Qaiser Shakeel: Plagiarism check and wrote fungal diseases.
Yasir Iftikhar: Language editing and finalization of the review.
Sonum Bashir: Wrote Nematodes and Plant-parasitic weeds.
Muhammad Ahmad Zeshan: Wrote fungal diseases.
Azhar Hussain: Validation and corrections of the review.

Conflicts of interest
The authors have declared no conflict of interest.

References

Abbas, A., 2017a. A report of powdery mildews on cucumbers in village Nomal, Gilgit Baltistan (GB)-Pakistan. Clin. Biotechnol. Microbiol., 1: 99-104.

Abbas, A., 2017b. A report of grey mold disease on grapes caused by *Botrytis cinerea* in Gilgit-Baltistan, Pakistan. Clin. Biotechnol. Microbiol., 1: 117-119.

Abbas, A., 2017c. First report of *Alternaria* blight of potatoes in nomal valley, Gilgit-Baltistan Pakistan. Appl. Microbiol., 3: 1-2. https://doi.org/10.4172/2471-9315.1000137

Abbas, A. 2018a. First report of gummosis disease of major fruits in Gilgit-Baltistan (GB) Pakistan. Int. J. Life Sci. Scient. Res., 2455: 1716. https://doi.org/10.21276/ijlssr.2018.4.3.11

Abbas, A., 2018b. First report of a smut disease on grasses in Gilgit-Baltistan, Pakistan. J. Plant Pathol. Microbiol., 9: 1-2. https://doi.org/10.4172/2157-7471.1000e112

Abbas, A., L. Khan and K. Sohail. 2015. Population

density of aphid (*Myzus persicae* Sulzer) and lady bird beetle (*Coccinella septempunctata*) on spring potato cultivars, Gilgit, Pakistan. J. Entomol. Zool. Stud., 3: 142-145.

Abbas, A., M.A. Sohail, , M. Mubeen, M. Alami, M. Umer and S. Khan. 2020. Plant viruses in Gilgit-Baltistan (GB) Pakistan: Potential future research direction. J. Plant Pathol. Microbiol., 10: 486. https://doi.org/10.35248/2157-7471.20.11.486

Abbas, A., S.A. Syed and Moosa. 2018. Emerging plant diseases of Gilgit-Baltistan (GB) Pakistan: A review. Agric. Res. Technol., 18: 1-6.

Akhtar, K.P., N. Ullah, M.Y. Saleem, Q. Iqbal, M. Asghar and A.R. Khan. 2019. Evaluation of tomato genotypes for early blight disease resistance caused by *Alternaria solani* in Pakistan. J. Plant Pathol., 101: 1159-1170. https://doi.org/10.1007/s42161-019-00304-8

Ali, H., K. Ahmed and A. Hussain. 2010. Incidence and severity of crown gall disease of cherry, apple and apricot plants caused by *Agrobacterium tumefaciens* in Nagar Valley of Gilgit-Baltistan, Pakistan. Pak J. Nutr., 4: 47-50. https://doi.org/10.3923/pjn.2010.577.581

Ali, S., T. Masud, K.S. Abbasi, T. Mahmood and A. Ali. 2014. Some physico-chemical and functional attributes of six indigenous apricot genotypes from Gilgit-Baltistan, Pakistan. Int. J. Biosci., 4: 221-231. https://doi.org/10.12692/ijb/4.2.221-231

Beltrán-Peña, H., A.R. Solano-Báez, M.Á. Apodaca-Sánchez, M. Camacho-Tapia, R. Félix-Gastélum and J.M. Tovar-Pedraza. 2018. First report of *Leveillula taurica* causing powdery mildew on cucumber in Mexico. J. Plant Pathol., 100: 353-353. https://doi.org/10.1007/s42161-018-0061-7

Butz, D.A. and N.E. Cook. 2011. Accessibility interrupted: The Shimshal road, Gilgit- Baltistan, Pakistan. J. Can. Geogr., 55: 354-364. https://doi.org/10.1111/j.1541-0064.2011.00365.x

Ejaz, S., S. Batool, M.A. Anjum, S. Naz, M.F. Qayyum, T. Naqqash, K.H. Shah and S. Ali. 2020. Effects of inoculation of root-associative *Azospirillum* and *Agrobacterium* strains on growth, yield and quality of pea (*Pisum sativum* L.) grown under different nitrogen and phosphorus regimes. Sci. Hortic., 270: 109401. https://doi.org/10.1016/j.scienta.2020.109401

Ezra, D., M. Hershcovich and D. Shtienberg. 2017. Insights into the etiology of gummosis syndrome of deciduous fruit trees in Israel and its impact on tree productivity. Plant Dis., 101: 1354-1361. https://doi.org/10.1094/PDIS-12-16-1836-RE

Farouk, S., B. Belal and H. El-Sharkawy. 2017. The role of some elicitors on the management of Roumy Ahmar grapevines downy mildew disease and it's related to inducing growth and yield characters. Sci. Hortic., 225: 646-658. https://doi.org/10.1016/j.scienta.2017.07.054

Fry, W.E., 2020. *Phytophthora infestans*: The itinerant invader; late blight: The persistent disease. J. Phytoparasitica, 48: 87-94. https://doi.org/10.1007/s12600-019-00778-3

Hussain, A., S. Ali, A. Hussain, Z. Hussain, M.F. Manzoor, A. Hussain, A. Ali, T. Mahmood, K.S. Abbasi, E. Karrar and M. Hussain. 2021. Compositional profile of barley landlines grown in different regions of Gilgit- Baltistan. Food Sci. Nutr., 50: 1550-1559. https://doi.org/10.1002/fsn3.2215

Hussain, A., S.W. Khan, M.S. Awan, S. Ali, Q. Abbas, Z. Ali and S. Ali. 2017a. Potato black scurf, production practices and fungi toxic efficacy of *Rhizoctonia Solani* isolates in hilly areas of Gilgit-Baltistan Pakistan. Pak. J. Bot., 49: 1553-1560.

Hussain, B., A. Abbas and S.U. Khan. 2019. First record of peach fruit fly in Gilgit-Baltistan (GB), Pakistan. J. Entomol. Zool. Stud., 7: 1-4.

Javed, S., A. Javaid, W. Anwar, R. Majeed, R. Akhtar and S. Naqvi. 2017. First report of *Botrytis* bunch rot of grapes caused by *Botrytis cinerea* in Pakistan. Plant Dis., 101: 1036. https://doi.org/10.1094/PDIS-05-16-0762-PDN

Joshi, S., W. Jasra, M. Ismail, R. Shrestha, S. Yi and N. Wu. 2013. Herders' perceptions of and responses to climate change in northern Pakistan. Environ. Manage., 52: 639-648. https://doi.org/10.1007/s00267-013-0062-4

Khan, M.R. and M.W. Khan. 1999. Effects of intermittent ozone exposures on powdery mildew of cucumber. J. Environ. Exp. Bot., 42: 163-171. https://doi.org/10.1016/S0098-8472(99)00029-5

Kieu, N.P., M. Lenman, E.S. Wang, B.L Petersen and E. Andreasson. 2021. Mutations introduced in susceptibility genes through CRISPR/Cas9 genome editing confer increased late blight resistance in potatoes. Sci. Rep.. 11: 1-12.

https://doi.org/10.1038/s41598-021-83972-w

Ma, X., X. Liu, P. Xiang, S. Qiu, X. Yuan and M. Yang. 2021. Effects of the contents of mineral elements on gummosis in *Prunus salicina* Lindl. Hortic. Sci., 56: 568-571. https://doi.org/10.21273/HORTSCI15649-21

Majeed, A. and Z. Muhammad. 2018. Potato production in Pakistan: Challenges and prospective management strategies. A review. Pak. J. Bot., 50: 2077-2084.

Mancero-Castillo, D., A. Sarkhosh, S. Sherman, M. Olmstead, P. Harmon and T. Beckman. 2018. Fungal Gummosis in Peach. EDIS. 2018. https://doi.org/10.32473/edis-hs1265-2018

Montarry, J., B. Mimee, E.G. Danchin, G.D. Koutsovoulos, D.T. Ste-Croix and E.J.P. Grenier. 2021. Recent advances in population genomics of plant-parasitic nematodes. Phytopathology, 111: 40-48. https://doi.org/10.1094/PHYTO-09-20-0418-RVW

Nabi, A., B. Padder, M. Dar and M. Ahmad. 2018. Morpho-cultural, pathological and molecular variability in *Thyrostroma carpophilum* causing shot hole of stone fruits in India. Eur. J. Plant Pathol., 151: 613-627. https://doi.org/10.1007/s10658-017-1398-z

Raza, W., M.U. Ghazanfar, L. Sullivan, D.E. Cooke, and L.R. Cooke. 2021. Mating type and aggressiveness of *Phytophthora infestans* (Mont.) de bary in potato-growing areas of Punjab, Pakistan, 2017-2018 and Identification of Genotype 13_A2 in 2019-2020. Potato Res., 64: 115-129. https://doi.org/10.1007/s11540-020-09467-9

Salim, M.A., S. Ranjitkar, R. Hart, T. Khan, S. Ali, C. Kiran, A. Parveen, Z. Batool, S. Bano and J. Xu. 2019. Regional trade of medicinal plants has facilitated the retention of traditional knowledge: Case study in Gilgit-Baltistan Pakistan. J. Ethnobiol. Ethnomed., 15: 6. https://doi.org/10.1186/s13002-018-0281-0

Shoaib, M., S. Mumtaz, A. Abbas, F. Begum and B. Hussain. 2020. Population density of free-living nematodes and their relationships with some soil physicochemical properties in forest and agriculture soils of Gapa Valley Chalt, Gilgit, Pakistan. Pure Appl. Biol., 10: 465-473. https://doi.org/10.19045/bspab.2021.100050

Subhani, M.N., S.T. Sahi, A. Rehman and W. Wakil. 2015. Effect of late blight caused by *Phytophthora infestans* (Mont.) de Bary on Phosphorus in leaves of advanced potato lines/cultivars. J. Agric. Sci., 3: 107-110.

Sun, G., Y. Xu, H. Liu, T. Sun, J. Zhang, C. Hettenhausen, G. Shen, J. Qi, Y. Qin, J. Li and L. Wang. 2018. Large-scale gene losses underlie the genome evolution of parasitic plant *Cuscuta australis*. Nat. Commun. 9: 1-8. https://doi.org/10.1038/s41467-018-04721-8

Takooree, S.D., H. Neetoo, V. Ranghoo-Sanmukhiya, S. Hardowar, J. van der Waals, V. Vally, A. Gungoosingh Bunwaree, M. Vojvodić, and A. Bulajić. 2021. First report of Black Scurf caused by *Rhizoctonia solani* AG-3 on potato tubers in Mauritius. Plant Dis., 105: 213. https://doi.org/10.1094/PDIS-06-20-1183-PDN

Ye, S., H. Jia, G. Cai, C. Tian and R. Ma. 2020. Morphology, DNA Phylogeny, and Pathogenicity of *Wilsonomyces carpophilus* Isolate Causing Shot-Hole Disease of *Prunus divaricata* and *Prunus armeniaca* in Wild-Fruit Forest of Western Tianshan Mountains, China. Forests, 11: 319. https://doi.org/10.3390/f11030319