بیماری‌های گیاهی / جلد ۵۹ / شماره ۴/ سال ۱۴۰۲: ۳۳۶-۳۲۵
DOI: 10.22034/ijpp.2024.2021809.457

CC BY

مقاله پژوهشی

توسعه بیماری بلاست در برخی از ارقام برنج ایرانی و افغانی در شرایط محیطی استان گیلان

صاحب‌شاه صیاد*، صدیقه موسی‌نژاد، سالار جمالی و فرزاد شیرزاد**

(تاریخ دریافت: ۱۴۰۳/۰۶/۱۳ ، تاریخ پذیرش: ۱۴۰۳/۰۹/۱۵)

چکیده

پیشرفت زمانی بیماری بلاست ناشی از قارچ *Pyricularia oryzae* Cavara در برخی از ارقام برنج ایرانی و افغانی در مراحل برگ و خوشه بررسی شد. برای این منظور ارقام هاشمی، کاظمی، آنام، صدری، سرخه، نیلوفر، سرخه دراز، شیرودی، کولی و شوله در مزرعه آزمایشی دانشگاه گیلان به صورت طرح بلوک‌های کامل تصادفی در فصول رشد ۱۴۰۰ و ۱۴۰۱ کشت شدند. از زمان مشاهده اولین علائم بیماری در کرت‌های آزمایشی، شدت بیماری بررسی شد و تا زمان برداشت با فواصل زمانی مشخص ادامه یافت. نتایج نشان داد که از نظر پیشرفت بیماری بین ارقام در مراحل برگ و خوشه تفاوت معنی‌داری وجود دارد. شدت اولیه، پیشرفت زمانی و شدت نهایی بلاست برگ در ارقام مورد مطالعه متفاوت بود. در هر دو سال مطالعه، رقم نیلوفر بیشترین حساسیت را به بلاست برگ نشان داد (۶۹/۱۶ درصد در سال ۱۴۰۱). ارقام سرخه، صدری و شوله نیز از حساسیت بالایی برخوردار بودند (به ترتیب ۳۱/۷۸، ۲۴/۷۵ و ۱۷/۲۷ درصد) و ارقام هاشمی و کاظمی حساسیت کمتری داشتند (به ترتیب ۶/۶۸ و ۵/۹۵ درصد). شدت بلاست برگ در ارقام سرخه دراز، آنام، کولی و شیرودی افزایش معنی‌داری نداشت. در مورد بلاست خوشه، رقم نیلوفر بر اساس شدت بلاست خوشه در این رقم، حساسیت بیشتری نسبت به سایرین نشان داد (۹۷/۴۶ درصد). پس از آن رقم سرخه دراز و کاظمی بیشترین شدت آلودگی خوشه را داشتند (به ترتیب ۱۸/۸۶ و ۱۷/۶ درصد). ارقام شوله، صدری، سرخه، هاشمی و آنام کمتر حساس بودند. ارقام شیرودی و کولی بیشترین مقاومت را نسبت به بلاست خوشه داشتند.

کلمات کلیدی: *Pyricularia oryzae*، بلاست برگ، بلاست خوشه، شدت بیماری، پیشرفت زمانی

**قسمتی از رساله دکتری نویسنده اول ارائه شده به دانشکده علوم کشاورزی دانشگاه گیلان*

**مسئول مکاتبات، پست الکترونیکی: mousanejad@guilan.ac.ir

گروه گیاهپزشکی، دانشکده علوم کشاورزی، دانشگاه گیلان، ایران

CC BY

DOI: 10.22034/ijpp.2024.2021809.457

Research Article

Blast disease development in some Iranian and Afghan rice varieties in Guilan province environmental conditions

Sahib Shah Sayad*, Sedigheh Mousanejad, Salar Jamali and Farzad Shirzad**

(Received: 19.06.2023; Accepted: 03.09.2024)

Abstract

Blast disease development caused by the fungus *Pyricularia oryzae* Cavara was determined in leaf and panicle stages in some Iranian and Afghan rice varieties. For this purpose, Hashemi, Kazemi, Anam, Sadri, Surkha, Niloofar, Surkha Long, Shiroudi, Koli and Shola varieties were grown at the experimental field of the University of Guilan in 2021 and 2022 growth seasons as a randomized complete block design. As the first disease symptoms were observed in experimental plots, disease severity was assessed and continued at specific intervals until harvest time. The results indicated a significant difference between varieties in disease development at the leaf and panicle stages. The initial severity, progression over time and final severity of leaf blast varied among the studied varieties. In both years of the study, the Niloofar variety showed the highest susceptibility to leaf blast (69.16% in 2022). Surkha, Sadri and Shola varieties showed high susceptibility as 31.78%, 24.75% and 17.27 and Hashemi and Kazemi had less susceptibility as 6.68% and 5.95%, respectively. There was no significant increase in the severity of leaf blast in the Surkha Long, Anam, Koli and Shiroudi. Regarding panicle blast in both years, Niloofar variety showed the highest susceptibility based on the panicle blast severity (97.46%) and then, Surkha Long and Kazemi varieties had the highest severity of panicle infection (18.86% and 17.6%, respectively). Shola, Sadri, Surkha, Hashemi, and Anam varieties were less susceptible. Shiroudi and Koli varieties were the most resistant to the panicle blast infection.

Keywords: *Pyricularia oryzae,* Leaf blast, Panicle blast, Disease severity, Temporal progress

*Corresponding author’s E-mail address: mousanejad@guilan.ac.ir
Department of Plant Protection, Faculty of Agricultural Sciences, University of Guilan, Iran

Introduction

Rice is the most widely consumed food crop. Asia accounted for 84% of global consumption followed by Africa (7%), South America (3%), and the Middle East (2%) [Bhandari, 2019]. In Iran, rice occupies a special place in people's daily diet. In 2022, the rice production in Iran was more than 2.5 Mt [Najafabadi *et al.*, 2022]. After Mazandaran and Guilan, the Golestan province with 14% of total rice production, is one of the biggest producers in Iran.

Approximately half of the Afghan economy depends on the agriculture sector. More than 80% of Afghans rely on agriculture-related activities for their livelihood [Alamyar and Boz, 2018]. There is approximately 8 million ha of arable land, of which 3.2 million ha are irrigated, with a total of 190,000 ha of cultivated lands providing 532,000 metric tons of paddy rice or 319,200 metric tons of milled rice [Kakar *et al*., 2019]. Rice consumption in Afghanistan has been gradually increasing owing to rapid population growth, with a high birth rate. As a result, Afghanistan may need to import 280,000 tons of rice annually by 2020 [JICA, 2018].

Rice is grown in Kunduz, Baghlan, Takhar, Nangarhar, Laghman, Khost and Herat provinces in Afghanistan, but Kunduz, Baghlan, Takhar, Nangarhar, and Laghman are the top five rice producing provinces in the country, which together account for approximately 81% of the total domestic rice production during 2011-12/2015-16. The average total milled rice consumed in the country during 2001-02/2013-14 is about 0.5 million tons of which 73% is produced domestically while the remaining is imported largely from Pakistan. However, due to predominant subsistence rice production, the low quality of local rice varieties, a tiny marketable surplus of local rice, and the paucity of modern rice processing mills, the country suffers from persistent deficits in rice production and appears far from attaining self–sufficiency in the near future [Hassanzoy *et al*., 2016].

Different factors such as pests, diseases, weeds, drought, losses during harvest, conversion, and storage, etc. cause a lot of loss in rice yield every year. Blast disease is the most important disease of rice in Guilan province which causes a lot of damages to susceptible cultivars of rice in two forms of leaf and panicle blast. The causal agent of the disease is *Pyricularia oryzae* Cavara (syn= *Magnaporthe oryzae* B.C. Couch). This disease causes immoderate loss on the susceptible local cultivars. Despite the introduction of resistant cultivars to the disease and development of the cultivation of such varieties in recent years, due to the very high quality of local cultivars, a large area of the province is allocated to the cultivation of these cultivars. Some of the cultivars such Khazar is resistant to leaf blast stage, but it is susceptible to panicle blast (Mousanejad *et al.*, 2009).

Afghan rice crops are also affected by different biotic and abiotic factors, which lead to the loss of huge amounts rice production yield. Among different diseases caused by microorganisms, rice blast disease is a momentous disease that predominates not only in Afghanistan but also across the globe. It is a contagious fungal disease that appears in irrigated land, rain-fed uplands, and on standing rice in deep water. Nowadays it is distributed all over Afghanistan, where rice is cultivated. Among fungal diseases, 50-90% of yield losses are due to rice blast disease [Kakar *et al*., 2019]. Severe epidemics of rice blast disease have occurred in Afghanistan and have resulted from substantial yield losses varying from 50 to 90 % [Kakar *et al*., 2019]. Although the disease is so severe in some parts of Afghanistan because of the critical condition, there is no information about rice blast epidemics in those areas and also about the Afghan local cultivars susceptibility or resistance to the disease.

Disease progress is a dynamic process over time. The disease temporal progress curve implicates a collection of effects of the host, pathogen, and environmental conditions on the disease progress during its period. So far temporal progress of many important plant diseases has been studied. Taliei *et al*. (2006) studied the temporal progress of *Fusarium* head blight in three different wheat cultivars and one resistant line over two years in Golestan province. Aghajani *et al*. (2010) studied the development of stem rot in canola caused by *Sclerotinia sclerotiorum* over two crop seasons in different areas of Golestan province and drew disease progress curves for these areas. Mojerlou *et al.* (2010) also studied the temporal progress of wheat leaf spot caused by *Septoria tritici* on five cultivars and two wheat lines during two years in field and greenhouse conditions in Golestan province. Temporal progress of diseases such as basal stem rot in the palm caused by Ganoderma spp. (Azahar *et al.,* 2011), the quick decline of citrus (with unknown etiology) (Bassanezi *et al*., 2005), citrus variegated chlorosis (caused by *Xylella fastidiosa*) (Gottwald *et al*., 2001), powdery mildew, and leaf rust in wheat (caused by *Blumeria graminis* f. sp. *tritici* and *Puccinia recondita* f. sp. *tritici,* respectively) (Franke *et al*., 2009), oak trees sudden death (caused by *Phytophthora ramorum*) (Xu *et al*., 2009), cashew gummosis (caused by *Lasiodiplodia theobromae*) (Cysne *et al*., 2010), peach rusty spot (caused by *Podosphaera leucotricha*) (Furman *et al*., 2003) and cassava mosaic virus disease (Fargette *et al*., 1994) have been studied and therefore very effective epidemiological information about mentioned diseases have been obtained.

Temporal analysis of blast disease progress in rice cultivars which have a large area of cultivation and drawing disease progress curves for cultivars lead to better recognition of disease susceptible stages, determination of disease severity in various phonological stages and final severity of leaf and panicle blast. Results of this kind of study can be effective in forecasting and also in better management of blast disease in the area and consequence decrease of chemical pesticides use and also reduction of environmental pollutions caused by excessive use of pesticides. There is no study about the temporal progress of rice blast disease in field conditions in Iran and also especially no study on this important disease in Afghanistan and on its rice varieties. Therefore, the purpose of this study was the determination of leaf blast and panicle blast disease progress over time in some Iranian and Afghan rice varieties. Due to the necessity of sufficient knowledge of the disease progress in natural conditions, disease temporal progress was analyzed at leaf and panicle stages under field conditions.

Materials and Methods

Implementation of the experimental plan

As part of an experimental design at the research farm of the Faculty of Agricultural Sciences, University of Guilan, randomized complete block designs were implemented during the growing seasons of 2021 and 2022. For the experiment, four varieties (Hashemi, Kazemi, Anam, and Shiroudi) were selected from Iranian cultivars. Additionally, seeds of six rice varieties (Surkha, Surkha Long, Sadri, Niloofar, Shula, and Koli) were collected from various rice-growing provinces of Afghanistan and transferred to Iran. In the first year, six varieties of rice as Hashemi, Kazemi, Anam, Sadri, Niloofar and Surkha were planted in three replicates in plots of 3 x 5 meters. In those six varieties, Sadri, Niloofar and Surkha local seeds were from Afghanistan, and the other three types of seeds (Hashemi, Kazemi and Anam) were obtained from the Faculty of Agricultural Sciences, University of Guilan. In the second year, five selected cultivars were from Afghanistan and only Shiroudi was from Iran. All the rice seeds were cleaned up and made ready for germination in the nursery. Meanwhile, the land was made ready for the transplanting of the rice and 18 plots were prepared for the six varieties. Plots were randomly allocated for each cultivar and three plots were made for each cultivar and named using a written blackboard.

For each of the Afghan and Iranian varieties, two kilos of seeds were considered. The plots of the mainland were separated with dimensions of 3 x 5 meters, with a distance of at least 1.5 meters between each plot and the adjacent plot and at least 2 meters from the edge of the field. The studied varieties were transplanted by hand at the same time and with a planting density of 20 x 20 cm in the designed plots of the mainland. Each of the Afghan and Iranian rice varieties was planted randomly in three replications. Triple superphosphate fertilizer was used at the rate of 100 kg per hectare before transplanting and also urea fertilizer at the rate of 150 kg per hectare during two stages before transplanting and before weeding. Butachlor herbicide was used at the rate of 3 liters per hectare four days after transplanting. Three steps of manual weeding were done by two weeks intervals after transplanting. To preserve the tillers for the data collection stage, 10% diazinon granules were used against the second generation of the rice striped stem borer at the rate of 15 kg per hectare.

Figure 1. Randomized rice plots in the experimental field of University of Guilan in the current study.

Data collection

In the leaf stage, data were collected from the plots five times weekly. In this stage, 20 tillers of each plot were cut off from the bottom and all the leaves of the tillers were examined according to the scale provided by the International Rice Research Institute (IRRI, 2002) in terms of disease severity. To minimize the error, no samples were taken from the marginal rows of the plots.

The leaf blast severity was calculated from equation a:

$S=\sum(x_i n_i)/N$ (a)

xi: the infected area of the leaf based on standard criteria (IRRI, 2002)

ni: number of leaves in each category

N: total leaves observed

After five times in the first year and seven times in the second year of data collection from the leaf blast, data collection from the panicle blast started. Data collection from the panicles was continued in both years of the research until the product was fully processed. Fifty panicles with three stages were collected weekly from each plot and the blast symptoms on the node, enter node, primary branches, secondary branches or the middle part of the panicle axis were observed and then the severity of the disease was calculated by the following equation:

$PBS=(10N_1+20N_3+40N_5+70N_7+100N_9)/N$

PBS = Panicle Blast Severity

N = Total no. of panicles observed

Scale (based on symptoms):

0 = No visible lesion or observed lesions on only a few pedicels

1 = Lesions on several pedicels or secondary branches

3 = Lesions on a few primary branches or the middle part of panicle axis

5 = Lesion partially around the base (node) or the uppermost internode or the lower part of the panicle axis near the base

7 = Lesion completely around panicle base or uppermost internode or panicle axis near the base with more than 30% of filled grains

9 = Lesion completely around the panicle base or uppermost internode or the panicle axis near the base with less than 30% of filled grains (IRRI, 2002)

Drawing the time progression curve of the disease

The obtained data were entered into the Excel software and the severity of the disease in different stages of leaf blast and panicle blast evaluation were calculated separately for each replication and the time progression chart of the disease was drawn for each variety and each replication. Then, the average severity of leaf blast and panicle blast in each stage of evaluation in different replications of each variety were calculated and the temporal progress of leaf blast and panicle blast in the studied varieties were drawn in a graph for comparison.

Results and Discussion

Outbreak of the disease

The weather conditions in both years of the research project implementation were such that blast disease occurred in the field during the susceptible stages of rice (leaves and panicles). In 2021, 27 days after transplanting, the first symptoms of the disease were observed in the leaf stage in experimental plots and data collection of the severity of the disease began. In the leaf phase, data collection was done from 18 plots weekly and five times. In 2022, data collection again started 27 days after transplanting from the leaf blast stage and for some cultivars, data collection continued seven times. The severity of the panicle blast was evaluated once every seven days and in the three stages based on the flowering date of the varieties.

Severity of leaf blast

The comparative graph of the time progression of the leaf blast for three Afghan and three Iranian varieties in 2021 is shown in Figure 2. The data collection was done every week. In the Niloofar variety, from the first until the second stage of data collection, the disease development was slow, but rapid development of leaf blast severity was observed from the second to fourth stage and the severity reached 46.30%. After the fourth stage, the disease progression again decreased. In the Sadri variety, the disease progression started at 0.1% and continuously ended at 24.75%. In the Hashemi variety, the disease progression started well from the first stage, but from the third to the last stage, there was no known development in the disease. In the Kazemi variety, the disease progression was slow and just reached 5.95%. In Surkha and Anam varieties, there was not so big gap and the disease continuously progressed from the first stage and reached 0.99% and 2.24%, respectively.

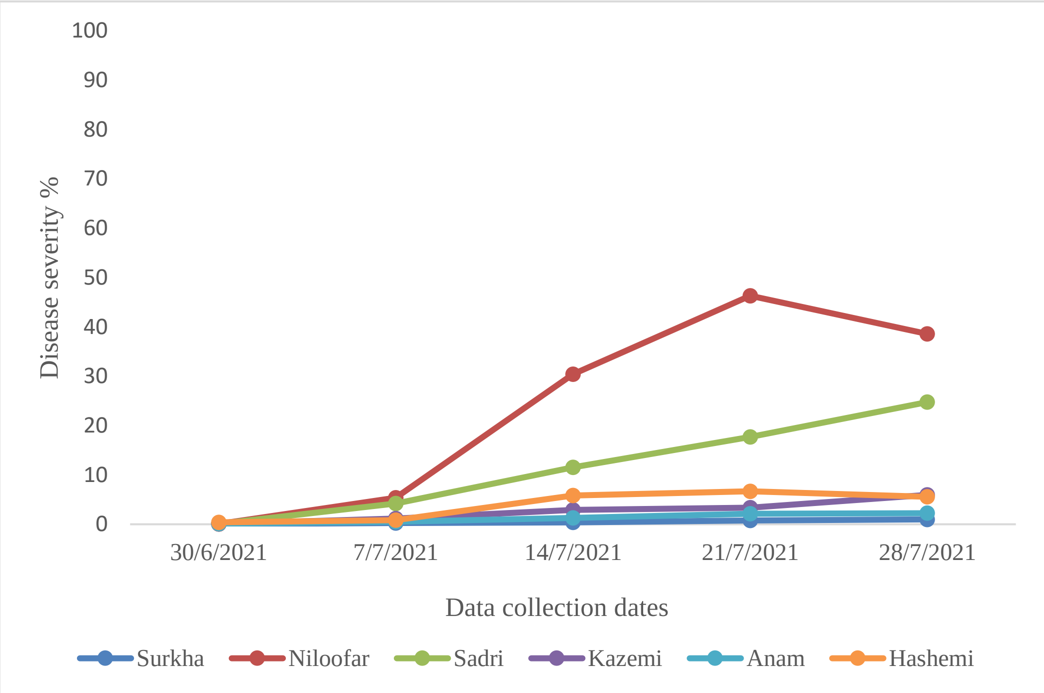

Figure 2. Time progression of leaf blast severity in Surkha, Niloofar, Sadri, Hashemi, Kazemi and Anam varieties in 2021.

The comparative graph of the time progression of the leaf blast for six Afghan and one Iranian varieties in 2022 is shown in Figure 3. The data collection of the leaf blast was done every week again this year. In the Niloofar variety, from the first until the third stage of data collection, the disease progression was slow, but the rapid development of leaf blast severity was observed from the third stage and reached 69.16%. In the Surkha variety, same as Niloofar, the disease was slow till the first three stages of data collection, but the disease developed well in the fourth week and reached 31.78% and again the disease was slow in the last week. In the Shola variety, the disease progression started from the third stage and reached 17.27%. In Sadri and Surkha Long varieties, there was not so big gap and continuous progression of the disease was observed from the first stage to the fourth stage of data collection and after the fourth stage, the disease progression was slow. In Koli and Shiroudi varieties, the disease development was not mentionable, because it was less than one percent.

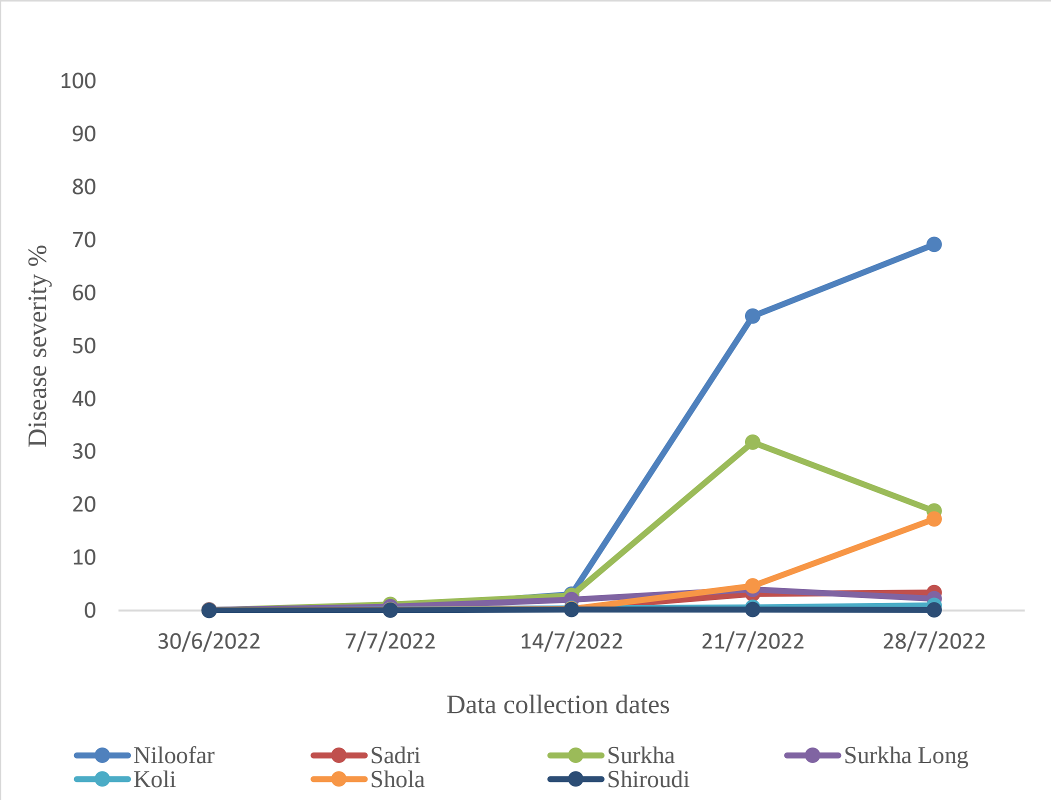

Figure 3. Time progression of leaf blast severity in Niloofer, Sadri, Surkha, Surkha Long, Koli, Shola and Shiroudi varieties in 2022.

Severity of panicle blast

The comparative graph of the time progression of the panicle blast for three Afghan and three Iranian varieties in 2021 is shown in Figure 4. The data collection was done every week. In the Surkha variety, the disease started and continued to the second stage rapidly but after the second stage, the disease was slower than the second stage of the data collection. In the Niloofar variety, the disease was rapidly in development and reached to 52.26% during data collection. In the Sadri variety, the disease progression started from 4.66% and continued upward to 5.53% and then slowed down in the last stage of data collection. In the Kazemi variety, the disease was slow in the first week, but after the first stage of data collection, the disease progression was high and it reached 17.8% in the last stage of data collection. Anam and Hashemi varieties were a bit the same in disease development. In the first week, Anam's disease severity was 1.53% and Hashemi's was 1.4, but in the last stage, in Anam variety, there was no known development, but in Hashemi variety, the severity increased and reached 6.13% during the data collection.

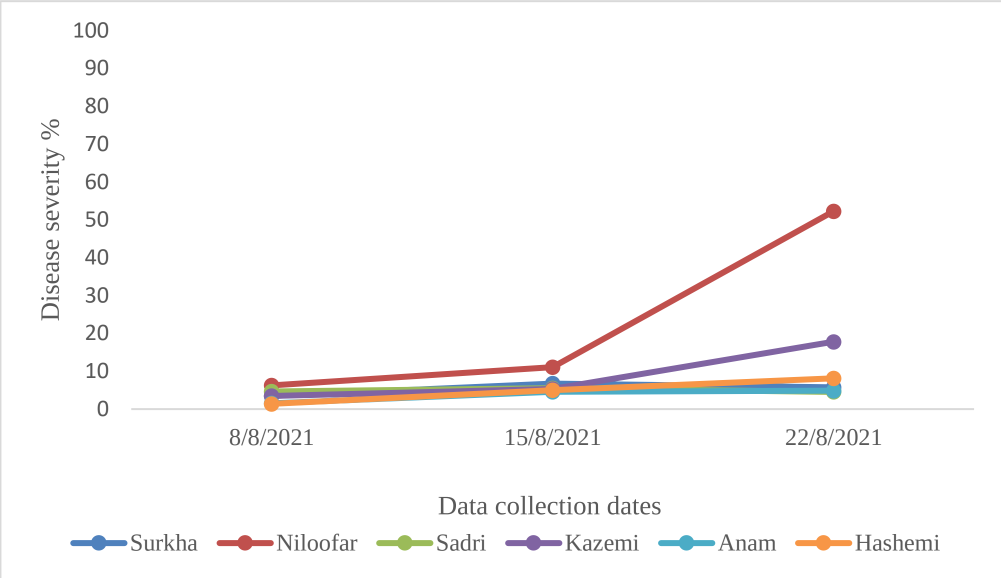

Figure 4. Time progression of panicle blast severity in Surkha, Niloofar, Sadri, Hashemi, Kazemi and Anam varieties in 2021.

Based on the severity of panicle blast in 2022, with data collected every seven days during three growth stages, the Niloofer variety showed the highest severity of panicle blast, similar to the previous year. Following Niloofer, Surkha Long, Sadri, Shola, Surkha, Shiroudi, and Koli were ranked according to the severity of the disease. The average severity of the disease in the first stage of data collection for Niloofar variety was 17.8%, and in the last stage, it reached 97.46%. The disease severity for Surkha Long was 0.0% in the first data and 18.86% in the last stage and for Sadri, 1.5% in the first data and 6.46% in the end stage. For Shola, the severity of the disease was 0.26% in the first data collection stage and 8.2% for the last stage. For Surkha, it was 0.13% in the first stage and 6.73% in the last stage, for Shiroudi, 0.0% in the first stage and 2.26% for the last, and for Koli 0.0% in the first and 0.33% for the last stage of data collection.

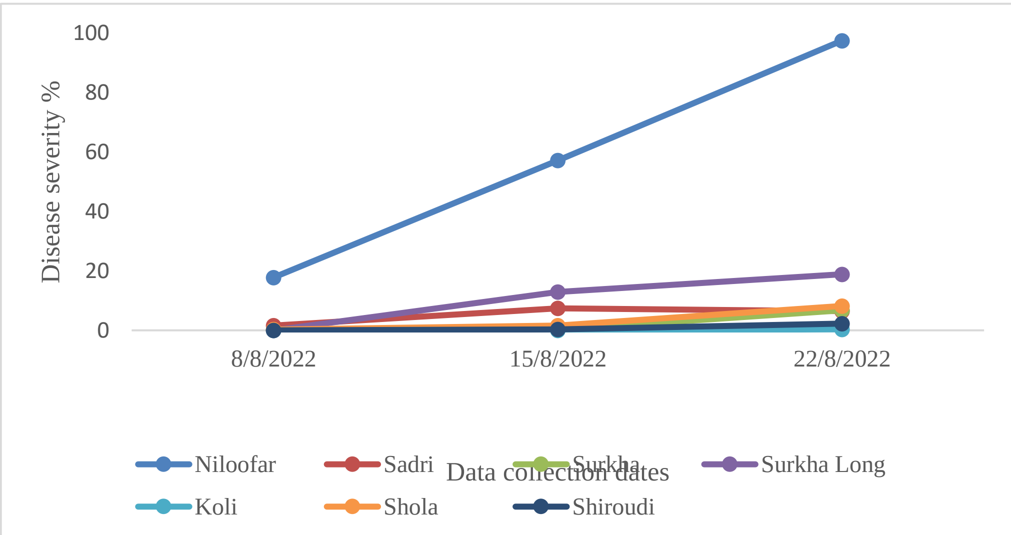

Figure 5. Time progression of panicle blast severity in Niloofar, Sadri, Surkha, Surkha Long, Koli, Shola and Shiroudi varieties in 2022.

Discussion

Rice blast disease, caused by *Pyricularia oryzae*, remains one of the most serious threats to rice production, leading to severe yield losses, particularly in endemic regions of the tropics and subtropics. Although effective chemical control measures have been developed, they are often too expensive, making host resistance the preferred strategy for disease management. It is considered as a no-cost technology, especially for the poor and marginal farmers and also an important component of the eco-friendly technique of integrated disease management program. Genetic analysis has resulted in the identification of several major genes governing resistance in the host plant, which function in a race-specific manner. Widespread cultivation of such cultivars possessing vertical resistance leads to the development of matching genes for virulence in the pathogen strains with strong ability to overcome the resistance in the host, ultimately resulting in the breakdown of resistance. Such instances of resistance breakdown have prompted plant pathologists and breeders to develop genotypes with rate-reducing resistance, which is believed to be more durable and stable (Mohapatra *et al*., 2008).

Assessment of rate-reducing resistance to rice blast disease, otherwise known as slow-blasting resistance, is accomplished by recording sequential observations right from the first day of disease initiation till end of the epidemic and characterization of the disease progress curves. Disease progress curve is a graphical plot of disease intensity (y) versus time (t). For many purposes, this is the primary depiction of an epidemic, serving to summarize the interactions of host, pathogen, and the biological and physical environment on disease development (Madden *et al*., 2007).

There is no study about the temporal progress of rice blast disease in field conditions in Iran and also especially no study on this important disease in Afghanistan and on its rice varieties. Then due to the necessity of sufficient knowledge of the disease progress in some Iranian and Afghan rice varieties in natural conditions, disease temporal progress was analyzed at leaf and panicle stages under field conditions in the experimental field of the University of Guilan.

According to the data collection results in 2021 and 2022, the emergence of leaf blast spots occurred on 4/7/2021 in the field, and this was in the conditions that the minimum daily relative humidity was above 60% and the maximum daily temperature was below 30 ºC. The results of this research are consistent with the results of the research conducted by Mousanejad *et al.* (2009) and other studies conducted around the world (Tsai and Su, 1984, 1985; Tsai, 1986; Calvero *et al.,* 1996).

As expected, the severity of leaf blast was different in the studied varieties. In both years 2021 and 2022, severe leaf blast severity was observed in the Niloofar variety, but as the disease progressed and the healthy leaf area decreased, the development of the disease slowed down. Due to the appearance of some new leaves in the tillers before the booting stage, the disease development increased again and finally reached about 46.30% in 2021. Also in the year 2022, the disease was more severe than in 2021 (about 69.16%).

The severity of leaf blast in the Surkha variety in the year 2021 looked like resistance due to the symptoms during the data collection, but in the year 2022, the disease was severe. During the first three stages, the disease was downward and after the fourth stage the disease got severe and significant progress was observed, and then the disease rate again decreased. This change in the disease may be due to the more favorable weather conditions for the blast development during the growth season of 2022.

In the Sadri variety in the year 2021, leaf blast started from the second week of data collection and the time progression of leaf blast severity in this variety was slow compared to other varieties continuously to the last week of data collection. The disease progressed almost linearly till the end of the leaf blast data collection. This type of progression can be attributed to the existence of a sufficient amount of healthy and susceptible surfaces for infection. The severity of the leaf blast in Sadri variety in the year 2022 was not as high as in the year of 2021 and had slow progression in all stages of data collection.

For the Shola variety in 2022, the leaf blast disease progression was slow, but significant progression was made in the period before the fourth stage of data collection. There was still slow progression in the first, second and third stages, and faster progression was observed in the fifth stage.

In the case of the Hashemi variety in 2021, there was no significant fluctuation in the disease curve from the first till the second stage. The leaf blast disease severity increased from the second and was continuously in progress till the fourth stage, but after the fourth stage, the disease was downward. In Kazemi variety in 2021, the leaf blast disease was downward in all stages. The disease progression started from the first stage and continuously was in progress till the last stage. As the disease progression was slow between the first and the last stage, the disease developed linearly except in the last stage, because the disease a bit increased.

The real-time of the leaf blast disease progression in Surkha Long in 2022 started from the second stage. The disease progression was downward continuously till the fourth stage and after the fourth stage, a somewhat upward trend was observed in the disease. For the Anam variety in 2021, no significant fluctuations were observed in the disease curve between the first and fifth stages of data collection, and the leaf blast disease developed almost linearly with a gentle slope. In the case of the Koli variety in 2022, an almost linear progression was observed with a steep slope between the first and fifth stages of data collection. From the disease curve, it seems that the Koli variety was resistant to the leaf blast disease.

According to Figure 3, it is clear that the Shiroudi variety is resistant to the leaf blast disease. There was no significant fluctuation in the disease curve between the first and fifth stages of data collection and the disease progressed almost linearly with a gentle slope same as in the Koli variety. The reduction of the healthy leaf surface can be considered as the reason for the disease slow down and then the regrowth of the leaves and the presence of the susceptible surface to infection as the reason for the re-increase of the disease.

The initial severity, time progression and final severity of leaf blast were different in the studied varieties. In both years of the study, the Niloofar variety showed the highest susceptibility to leaf blast and the increase in the severity of the disease over time in this variety was faster than the others. After that, Surkha, Sadri and Shola varieties had high susceptibility, respectively. Hashemi and Kazemi varieties had less susceptibility than the Niloofar, Surkha, Sadri and Shola. As expected, there was no significant increase in the severity of leaf blast in the Surkha Long, Anam, Koli and Shiroudi varieties.

Regarding panicle blast in both years of the study, the Niloofar variety showed higher susceptibility in both years than the other studied varieties and the upward trend of panicle blast severity in this variety was faster compared to others. This high severity is related to the Niloofar's high susceptibility to blast disease and the late ripening of this variety. After that, Surkha Long and Kazemi varieties had the highest severity of panicle infection. Shola, Sadri, Surkha, Hashemi, and Anam varieties were less susceptible than the above-mentioned ones. The Shiroudi and Koli varieties were the most resistant to the panicle blast in all studied varieties.

Niloofar in the year 2021, showed an upward trend in panicle blast severity continuously from the first to the third week of data collection. In the year 2022, the disease severity of the panicle blast continuously increased till the last stage of data collection as the year 2021. In Surkha Long variety, there was no disease in the first week of data collection. The disease progression started in the second week and the disease severity was high in the two last stages of the panicle blast disease data collection. In the Kazemi variety, the progression of the panicle blast disease started from the first stage of data collection and the disease severity showed progression till the last week of the data collection. In the case of the Shola, same as the Kazemi variety, the disease of panicle blast appeared in the first week of data collection and continuously progressed upward.

For the Sadri variety, in the year 2021, the panicle blast disease progression was about the same in the first and third weeks of data collection. In the year 2022, the disease started from the first week and till the second stage, the disease severity progression was upward, but after the second week, the disease development decreased. For the Surkha variety, in the year 2021, the panicle blast disease progression started from the first week and the disease severity looked like Sadri variety. The panicle blast progression was high till the second stage, but after the second stage, the disease progression decreased. In the year 2022, the disease progression started from the first week and continuously progressed to the last week of data collection. In the case of the Hashemi variety, the panicle blast disease continuously progressed from the first week till the last stage and the progression curve was linear. Anam variety was somewhat resistant to the panicle blast. The disease progression started in the first week and continued slowly to the second stage and after the second stage, the disease got downward.

The Shiroudi variety was not so susceptible to the panicle blast disease. The disease was present but not severe. There were no disease symptoms in the first week during data collection. The disease progressed in the second and third weeks but very slowly and the disease progression curve was linear. Koli was the only variety that was resistant to the panicle blast disease. There was no disease intensity in the first and second weeks of data collection and the disease progression started in the third week.

Considering the final severity of leaf and panicle blast in both years, the role of weather factors in the prevalence, severity and time progression of the disease is clearly felt. In 2022, the average final severity of the Niloofar leaf blast was higher than in 2021, and this value was the highest of all varieties in both years. In 2021, the final average severity of the leaf blast of Niloofar was 38.30%, and in the year 2022, the average severity of the leaf blast was 69.16%, respectively on 25/7/2021 and 28/7/2022.

Regarding the final severity of the panicle blast in Niloofar in 2022, the average final severity of the panicle blast was higher than in 2021, and this value was the highest of all varieties in both years. In 2021, the final average severity of the panicle blast of Niloofar during the data collection was 52.26%, and in the year 2022, the average severity of the panicle blast was 97.46%, respectively on 22/8/2021 and 22/8/2022.

According to García-Guzmán *et al*. (2016), environmental factors are effective in the survival, vital force, speed of reproduction, ease, direction, and distance of spread of the pathogen, as well as the rate of germination and penetration, and as a result, the development of the disease. Therefore, the difference in the environmental conditions during the years of conducting these experiments may justify the dissimilarity of the results. Since one of the goals of epidemiological analysis is to investigate the effect of environmental conditions on the development of the disease (Reynolds and Madden, 1988; Nelson, 1995), such experiments are carried out over consecutive years to compare the total results obtained in different conditions, then critical time and optimal conditions for the disease can be determined using the meteorological table for each region. In this way, it is possible to predict the non-occurrence of the disease, the possibility of its occurrence, or its definite occurrence in the future, which is the main goal of early warning systems [Pokhrel, 2021].

Acknowledgement

This paper is made ready based on the results of the first author's Ph.D. thesis as an international student in the University of Guilan. The authors thank the Deputy of Research of the university for funding the study and making ready the facilities, especially the research farm.

References

Aghajani, M. A., Safaie, N. and Alizadeh. A. 2010. Disease progress curves of *Sclerotinia* stem rot of canola epidemics in Golestan province, Iran. Journal of Agricultural Science and Technology, 12: 471-478.

Alamyar, R. and Boz, I. 2018. Problems and solutions in rice production and marketing in Takhar province of Afghanistan. Middle East, 2 (2,455): 2-475.

Azahar, T. M., Jawahir, C. M., Mazliham, S. and Boursier, P. 2011. Temporal analysis of basal stem rot disease in oil palm plantations: An analysis on peat soil. International Journal of Engineering and Technology, 11(3): 96-101.

Bassanezi, R. B., Bergamin Filho, A., Amorim, L. and Gotwald, T. R. 2005. Spatial and temporal analyses of citrus sudden death in Brazil. Sixteenth IOCV Conference, 217-229.

Bhandari, H. 2019. Global rice production, consumption and trade: trends and future directions. In: Proceedings of the Korean Society of Crop Science Conference (pp. 5-5). The Korean Society of Crop Science.

Calvero S. B. Jr., Coakley S. M. and Teng P. S. 1996. Development of empirical forecasting models for rice blast based on weather factors. Plant Pathology, 45: 667–678.

Cysne, A. Q., Cardoso, J. E., Maia, A. H. N. and Farias, F. C. 2010. Spatial-temporal analysis of gummosis in three cashew clones at northeastern Brazil. Journal of Phytopathology, 158: 676-682.

Fargette,D., Jeger, M., Fauquet, C. and Fishpool, L. D. C. 1994. Analysis of temporal disease progress of African cassava mosaic virus. Phytopathology, 84: 91-98.

Franke, J., Gebhardt, S., Menz, G. and Helfrich, H. P. 2009. Geostatistical analysis of the spatiotemporal dynamics of powdery mildew and leaf rust in wheat. Phytopathology, 99(8): 974-984.

Furman, L. A., Lalancette, N. and White, J. F. Jr. 2003. Peach rusty spot epidemics: Temporal analysis and relationship to fruit growth. Plant disease, 87: 366-374.

García-Guzmán, G., Trejo, I., Acosta-Calixto, I. and Sánchez-Coronado, M. E. 2016. Environmental factors associated with disease incidence in plant species from a Mexican seasonal tropical dry forest. The Journal of the Torrey Botanical Society, 143(3): 254–264. http://www.jstor.org/stable/26305713

Gottwald, T. R., Gidtti, F. B., Santos, J. M. and Carvalho, A. C. 2001. Preliminary spatial and temporal analysis of citrus variegated chlorosis (CVC) in Sao Paulo, Brazil. Twelfth IOCV Conference, 327-335.

Hassanzoy, N., Ito, S., Isoda, H. and Amekawa, Y. 2016. A comparison of asymmetric price transmission from global to domestic markets between high- and low-quality grains: A case of Afghan rice markets. Economics Bulletin, 36(1): 537-552.

IRRI. (2002). Standard Evaluation System for Rice (SES), International Rice Research Institute.

JICA. 2018. Terminal Evaluation Report on The Project for Rice-based Agriculture Development in Afghanistan Technical (RIPA). Ministry of Agriculture, Irrigation and Livestock (MAIL).

Kakar, K., Xuan, T. D., Haqani, M. I., Rayee, R., Wafa, I. K., Abdiani, S. and Tran, H. D. 2019. Current situation and sustainable development of rice cultivation and production in Afghanistan. Agriculture, 9(3): 49.

Madden, L. V., Hughes, G. and Van Den Bosch, F. 2007. Temporal Analysis I Quantifying and Comparing Epidemics. in: The Study of Plant Disease Epidemics American Phytopathological Society (APS). pp. 63-116.

Mohapatra, N. K., Mukherjee, A. K., Suriya Rao, A. V. and Nayak, P. 2008. Disease progress curves in the rice blast pathosystem compared with the logistic and Gompertz models. ARPN Journal of Agricultural and Biological Science, 3(1): 28-37.

Mojerlou, S., Safaie, N., Akizadeh, A. and Khelghatibana, F. 2010. Temporal analysis of Septoria leaf blotch progress in wheat. Agricultura Tropica et Subtropica, 43(4): 266-276.

Mousanejad, S., Alizadeh, A. and Safaie, N. 2009. Effect of weather factors on spore population dynamics of blast fungus in Guilan province. Journal of Plant Protection Research, 49(3): 319-329.

Najafabadi, M. M., Sabouni, M., Azadi, H. and Taki, M. 2022. Rice production energy efficiency evaluation in north of Iran; application of Robust Data Envelopment Analysis. Cleaner Engineering and Technology, 6, 100356.

Nelson, S. C. 1995. Spatiotemporal distance class analysis of plant disease epidemics. Phytopathology, 85(1): 37-43.

Pokhrel, B .2021. Effects of environmental factors on crop diseases. Journal of Plant Pathology and Microbiology, 12: 553-557.

Reynolds, K. M. and Madden, L. V. 1988. Analysis of epidemics using spatio-temporal autocorrelation. Phytopathology, 78: 240-246.

Taliei, F., Alizadeh, A., Safaie, N. and Dehghan, M. A. 2006. Temporal analysis of *Fusarium* head blight epidemics. Agricultural Sciences, 37(5): 811-820.

Tsai W. H. 1986. Prediction of rice leaf blast. 3. Meteorological variables and percentage of leaf area infected by *Pyricularia oryzae*. Plant Prot. Bull. Taiwan, 26: 171–180.

Tsai W. H. and, Su H. J. 1984. Prediction of rice leaf blast. 1. Meteorological variables and the development of the number of lesions. J. Agric. Res. China, 34: 71–78.

Tsai W. H. and Su H. J. 1985. Prediction of rice leaf blast. 2. The relationships of meteorological variables, conidial numbers and the development of the number of lesions. J. Agric. Res. China, 34: 71–78.

Xu, X., Harwood, T. D., Pautasso, M. and Jeger, M. J. 2009. Spatio-temporal analysis of an invasive plant pathogen (Phytophthora ramorum) in England and Wales. Ecography, 32: 504-516.