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Period of Appearance of the Main Fungal Diseases on Wheat in Two Regions with Sub-humid and Semi-arid Bioclimatic Levels (Tizi-ouzou and Bouira) in the North of Algeria

Kherroubi Samia[1], Medjdoub-Bensaad Ferroudja[1]

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ABSTRACT

Background: Cereal cultivation has been and will remain the predominant crop in Algerian agriculture. It constitutes the staple food of the majority of the population. However, this crop is subject to many abiotic and biotic constraints, including climatic factors as well as fungal, bacterial and viral diseases that cause considerable losses. The objective of the study is to carry out surveys and identify diseases on durum wheat and soft wheat plots in the Tizi-ouzou and Bouira regions.

Methods: Thus, 8 plots of the wilaya of Tizi-ouzou and 5 others of the wilaya of Bouira are subject to it, taking into account the precipitations and temperatures which favor the triggering and development of cryptogamic diseases on certain varieties of wheat. The identification of diseases is carried out by a macroscopic observation on the ground of the different symptoms manifested on the affected organ and a microscopic observation in the laboratory by a mycological examination on different culture media to confirm the presence of the pathogenic agent.

Result: The results obtained showed the impact of precipitation and temperatures on the period of appearance and development of diseases as well as the rate of infestations. The main cryptogamic diseases observed during monitoring were powdery mildew *Erysiphe graminis*, septoria leaf spot *Septoria tritici*, halo spot *Pyrenophora tritici* repentis, fusarium leaf spot *Fusarium* sp. and yellow rust *Puccinia striiformis*.

Key words: Abiotic factors, Diseases, Identification, Pathogens, Wheat.

INTRODUCTION

Cereals are vital and strategic resources in Algeria, their consumption continues to grow due to a strong demographic dynamic that the country (Chabane and Boussard, 2012). Durum wheat (*Triticum turgidum* var. *durum*) is the most cultivated species in the Mediterranean basin (Bonjean *et al.*, 2016). Wheat production was going upward direction over the years which shows Rajasthan framers were interested to produce wheat crop (Devendra *et al.,* 2025). In Ethiopia, 4.9 million smallholder farmers rely on wheat for employment, contributing to 20.2% of total production and 12.2% of the harvested area (1.9 million ha) (Marsimoy Ajema *et al.*, 2025).

In Algeria, the agricultural area represents only a little less than 3.6% of the total surface area of the country and only 30% of this surface receives more than 400 mm of rain per year. Cereal growing, dominated by durum wheat, represents 85% of the UAA and is located in semi-arid areas, characterized by random and deficit rainfall (Bessaoud, 2019). On average at the global level, despite crop protection, 42.54% of production is lost, due practically for a share of 13.5%, to diseases. In Algeria, about 30% of agricultural production is lost due to harmful agents and unfavorable climatic conditions (Rastoin and Benabderrazik, 2014). According to Ouffroukh (2008), cereals can be attacked by many diseases and at different stages of their development cycle. When a pathogen comes into contact with a plant in environmental conditions favorable to infection, the molecular dialogue between the host and the parasite begins, the outcome of which will define the type of relationship that will be established between the two protagonists (Le Poivre, 2003).The aim of the study is to establish a technical sheet showing the periods of appearance of durum and soft wheat diseases and the periods of adequate interventions.

[1]Production Laboratory, Safeguarding of Endangered Species and Crops, Influence of Climatic Variations, Faculty of Biological Sciences and Agronomic Sciences, Mouloud Mammeri University of Tizi-Ouzou, 15000, Algeria.

Corresponding Author: Kherroubi Samia, Production Laboratory, Safeguarding of Endangered Species and Crops, Influence of Climatic Variations, Faculty of Biological Sciences and Agronomic Sciences, Mouloud Mammeri University of Tizi-Ouzou, 15000, Algeria. Email: samia.kherroubi@ummto.dz

ORCIDs: https://orcid.org/0009-0006-1316-4583, https://orcid.org/0000-0002-9396-3775

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MATERIALS AND METHODS

The work was carried out during the year 2022 at the regional plant protection station located in Drâa Ben Khedda in the wilaya of Tizi-ouzou in Algeria.

The study consists of identifying the main diseases of durum and soft wheat, which consists of carrying out field trips and prospecting several plots in two different regions Tizi-ouzou and Bouira during the 2021-2022 agricultural campaign (Fig 1).

Tizi-ouzou region

03 plots located in ath zellal, including one plot of durum wheat with the Semito variety (G4) and 02 plots of soft wheat with the HD 1221 variety). In Bouzerzour02 plots of durum wheat with the semito (R1) and vitron (R1) varieties. AtTazmalt El Kaf 02 plots of durum wheat, one with the Semito variety and the other vitron and 01 lot in azazga of soft wheat with the HD1221(G4) variety.

Bouira region

In Bechloul 04 plots of soft wheat with the maouna, Arz (G4), arz varieties and one plot of durum wheat with the Core variety.01 plot in ouled Maakaci consisting of durum wheat with the Semito variety.

The samples were collected during March, April and May in 2022.

Equipment needed in the laboratory

The laboratory equipment was chosen according to the type of manipulations, to prepare the culture medium the glassware (Petri dishes, test tubes, slides and coverslips, beakers, *etc*.), the stirrer, the autoclave and some specific products were used. For the identification of diseases, a light microscope was used.

This method consists of taking 40 cereal stems in the diagonal of the plot, then examining the three fully developed upper leaves and counting the affected leaves.

The isolation of the pathogen was done from fragments of leaves or stems of different organs of the plant showing symptoms characteristic of each disease, such as leaves for septoria leaf spot, halo spot, rusts.

During the first isolation of pathogens, PDA medium is used considered as a standard medium for the development of fungi.

Sample disinfection and drying

After visual examination of the organ affected by the pathogen, the leaf part is cut out as well as the fragments of the collar under sterilized conditions to avoid heavy contamination. They are soaked in a 2% sodium hypochlorite solution and then rinsed three times with distilled water for 5 minutes to remove all traces of sodium hypochlorite. Disinfection, isolation and drying were carried out under aseptic conditions with zero pathogens.

Isolation on culture media

The different fragments that we prepared were directly transferred into petri dishes containing the PDA culture medium. The dishes are incubated in the incubator at 25°C for five to seven days to allow the development and fruiting of the fungus.

Methods for identifying isolates

The identification of a representative strain is carried out by macroscopic identification that allows to determinate the texture (velvety, woolly, *etc*.), the color of the thallus (pigmentation of the mycelium, color of the conidia) during development as well as the color of the reverse of the culture and its odor (Botton *et al*., 1990).

Microscopic identification

A small piece of scotch tape is applied by its sticky side on the colony using forceps, then placed on a drop of Lactophenol blue cotton on a clean slide. The light is heated by passing the slide over a weak flame of a bunsen burner without letting the dye dry on the slide. Subsequently the prepared slides will be observed under the optical microscope at different magnifications up to immersion (G × 100). This type of identification is based essentially on the morphological study of the mycelium (absence or presence of partitions, color, mode of branching, differentiation of thallospores, etc.) and the spores (shape, color, texture of the walls, grouping in chains, *etc*.).

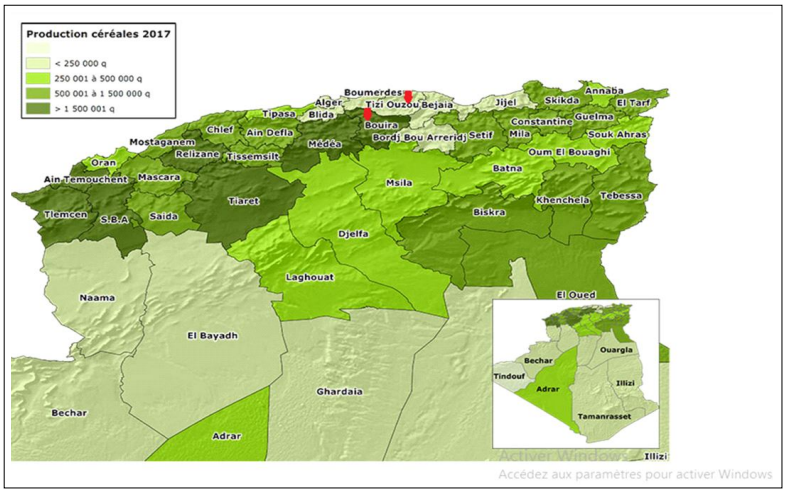

Fig 1: National cereal production by zone (MADR, 2017).

Climate study of the Tizi-ouzou and bouira regions

Climatic factors play an important role in the development of fungal diseases of cereals; favored by temperature and humidity and their dispersion by meteorological phenomena, especially with extreme episodes, cyclones and storms.

Tizi-ouzou is one of the coldest regions in Algeria, with an average maximum daily temperature of only 23°C. For a long period of the year, temperatures are constantly above 25°C and can reach 35°C.The region received little and irregular rainfall with a cumulative total of 486.3 mm of rain during the year 2022. The wettest months are April and November with a cumulative total of 102.1 mm and 102.2 mm respectively. The summer period is marked by a low precipitation rate. The summer period is marked by an absence of precipitation corresponding to the cereal harvest period.

The average temperature of the lowest month in the Bouira region is noted in January with an average of 8.7°C and the minimum being 2.3°C. The hottest month is July with an average temperature of 29.9°C and the maximum being 27.3°C. In Bouira region the lowest value is noted in January with 8.7°C constituting the coldest month and the highest value is noted in July with an average temperature of 29.9°C. The precipitation of the Bouira region 339.4 mm is low and irregular during the year 2022; the wettest months are March and April with 56.3 and 90.5 respectively. The summer period is marked by low precipitation values.

RESULTS AND DISCUSSION

The different fungal diseases recorded and identified respectively in the region of Tizi-ouzou and Bouira are shown in the following.

During the surveys carried out in the field in the Tizi-ouzou region, three diseases were identified, namely septoria, halo spot and powdery mildew. In the Bouira region, three diseases were noted, namely septoria, powdery mildew and yellow rust.

The results presented in show that the fungal diseases identified in the Tizi-ouzou region are Septoria on 04/19/2022, on durum wheat varieties Semito R1 and Semito at the rise and end of tillering stages with a respective attack percentage of 20% and 10%. At the tillering and end of tillering stages respectively for the vitron varieties the attack percentage of the same disease was 25%. The attack percentage of septoria on soft wheat with the HD 1221 G4 and HD 1221 varieties was 30% and 10% respectively at the end of tillering stage.

Also, powdery mildew was observed at the same time as Septoria on durum wheat variety semito R1 at the heading stage with an attack percentage of 20% and 30% on soft wheat variety HD 1221 G4. On 04/26/2022, symptoms of Haloed task were observed on soft wheat variety HD 1221 at the end of tillering stage with an attack percentage of 10% and in durum wheat variety semito G4 at the end of tillering stage with an attack percentage of 15%.

The results show the presence of the different diseases recorded during the outings carried out in the Bouira region. The diseases are observed on durum wheat varieties Semito and Core, soft wheat varieties maouna, Arz (G4) and arz at different phrenological stages, namely heading, tillering, flowering and milky-pasty with different attack percentages. As of 05/09/2022, Septoria is observed in the durum wheat plot variety Semito at the end of tillering stage with an attack percentage of 20%.

On 05/09/2022, Powdery Mildew was observed in the durum wheat plot of the Semito and Core varieties at the end of tillering and tillering stages with an attack percentage of 20% and 10% respectively. Yellow rust was observed on the same date, on soft wheat varieties maouna, arz G4 and arz at the milky-pasty stage with an attack percentage of 20% for the Maouna variety and some traces of rust on arz and arz G4.

Fig 2 shows the rate of infestation of different diseases on several varieties of wheat in the Tizi-ouzou region.

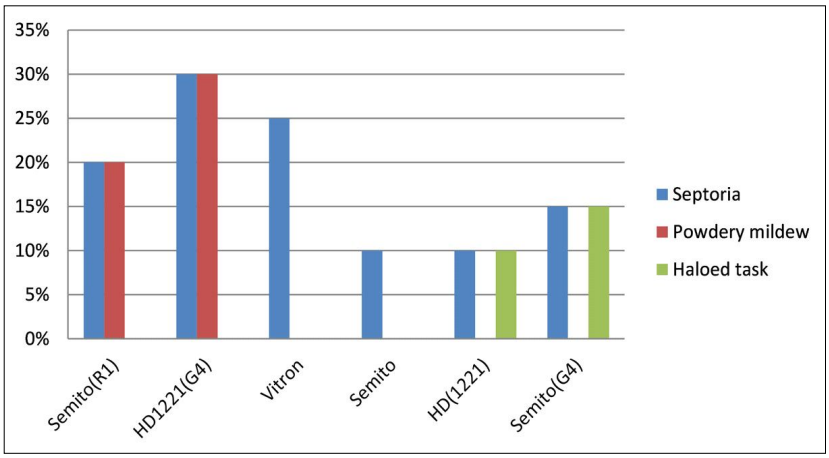

Fig 2: Infestation rate by different diseases on different wheat varieties in the Tizi-ouzou region.

It is to be noted through this figure that the infestation rate of Septoria is 30%, powdery mildew is 20% and the halo spot is 10%. Also, the appearance of Septoria was reported on all varieties, with a very high infestation percentage, 30% in soft wheat variety HD1221 (G4), 25% in durum wheat variety vitron, 20% on the semito variety (R1) and with low rate (10% and 15%) on the semito variety. Powdery mildew was observed on both cereal species, durum wheat variety Semito (R1) with an infestation rate of 20% and on soft wheat variety with HD 1221 G4 30%. Halo spot was recorded in two plots of durum and soft wheat, including 15% in durum wheat variety semito (G4) and 10% in soft wheat variety HD 1221.

In the Tizi-ouzou region the appearance of fungal diseases is observed from the tillering stage with a high infestation rate compared to the heading stage (Fig 3). It should be noted that septoria was observed at the end of tillering with a very high infestation rate (30%). At the bolting stage, the infestation rate reached 20%. Powdery mildew was observed at the end of tillering and at the bolting stage with infestation rates of 30% and 20% respectively. For halo spot, it should be noted that at the bolting stage there is a total absence of symptoms of the disease. At the end of tillering stage the disease appears but with a low infestation rate of 15%.

The results presented in Fig 4 indicate the rate of infestation of fungal diseases of wheat in the Bouira region.It should be noted that the main diseases that appeared were Septoria, powdery mildew, yellow rust with respective infestation rates of 20%, 30%, 20% and 30% in durum wheat variety Semito and 10% on durum wheat variety core. Septoria was recorded only on durum wheat variety semito with an infestation percentage equal to 20%. Yellow rust was recorded in three plots of durum and soft wheat, including 20% on soft wheat variety Maouna and some traces on soft wheat variety arz and arz G4.

Fig 5 shows the rates of fungal disease infestations recorded during all stages of wheat development in the Bouira region.

The results show that the tillering stage is the most infested by diseases with 10%. Then comes the late tillering and milky pasty stages. It should also be noted that powdery mildew is the first disease observed during May, it appeared at the tillering stage on certain varieties with an infestation rate of 30%. This infestation rate decreased with the development of the plant (20% at the late tillering

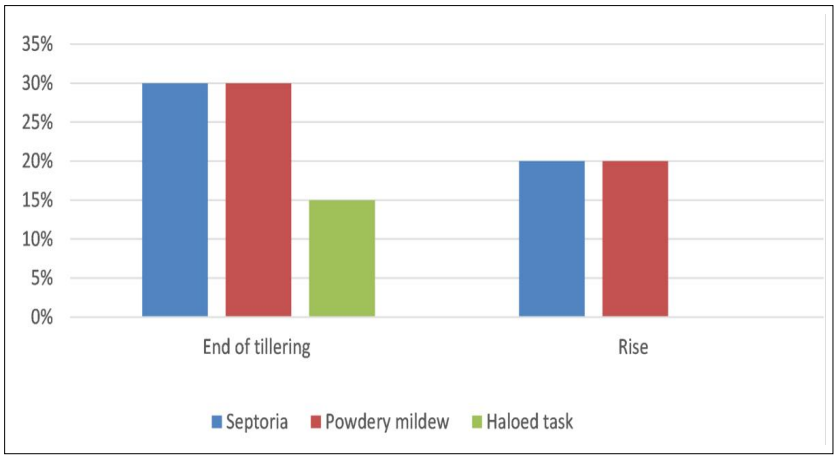

Fig 3: Fungal disease infestation rates recorded during the wheat development stages in the Tizi-ouzou region.

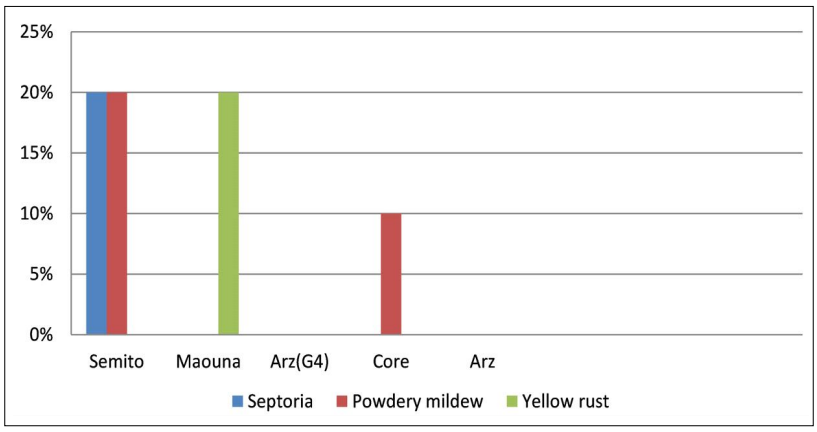

Fig 4: Fungal disease infestation rates in the Bouira region.

stage). For yellow rust, it should be noted that during May, at the tillering and heading stage, the symptoms of the disease are completely absent until the milky pasty stage where the disease appears with a low infestation rate of 20%.

Laboratory diagnosis

The work in the laboratory consists of carrying out macroscopic and microscopic observations of all the diseases studied. The observations are based on the different morphological symptoms that appear on the organ affected by the pathogen. For this, 5 Petri dishes were used to carry out several tests, with observation of the colonies developed on the different culture media used to examine all the morphological characteristics of the fungi according to the appearance of the colonies.

Powdery Mildew: Erysiphe graminis

Macroscopic observation

Monitoring the development of Powdery Mildew on a plot of Semito durum wheat, the first sample of which was harvested on April 19, 2022. It was noted that Powdery Mildew can attack cereals throughout the crop. It is an obligate fungus that develops on the upper surface of the leaves and on the stem. White felting was observed with a gray-white cottony fungal growth, on isolated areas of the contaminated leaf. Subsequently, these spots extend until a significant part of the leaf is covered. Later, Powdery Mildew forms in the old pustules black-brown globular bodies called cleistothecia.

Yellow rust *Puccinia striiformis*

Macroscopic observation

The symptoms do not appear during the winter, are often only presented during the spring, symptoms of yellow rust were observed 09.05 .2022 on two varieties of soft wheat arz and maouna located in Bouira. The symptoms on the leaves are characterized by the presence of elongated yellow-orange pustules aligned along the veins of the leaves in the form of streaks with a powdery appearance. It has been noted that the pustules develop both on the underside of the leaves and on the ears.

Microscopic observation

After microscopic examination, urediniospores of *P. striiformis* are observed, they are single-celled, globose to oval, rarely ellipsoid, with a finely rough thick wall.

Septoria

Description of symptoms

The first sample showing symptoms of Septoria was observed on April 19, 2022 on a plot of durum wheat variety semito (R1) in the Tizi-ouzou region. Some irregular rectangular chlorotic spots of necrotic brown color are observed, above these necrotic areas there are black punctuations. These are pycnidia. The second sample collected in Bouira which presents the same symptoms as the first sample but at a slightly advanced stage in the form of larger spots and more condensed pycnidia. To ensure that such symptoms are caused by the Septoria pathogen, a mycological examination in the laboratory is carried out.

Halo spot

Description of symptoms

The main symptoms are manifested by the appearance of oval or elongated spots on the leaf blade. These spots subsequently take on a bronze appearance with a yellow halo on its edge and a darker spot in the middle.

The results obtained during the surveys carried out in the durum wheat and soft wheat plots in the two regions of Tizi-ouzou and Bouira show the presence of some fungal diseases with different percentages of attacks. Three fungal diseases are identified in Tizi-ouzou region, namely Septoria, powdery mildew and halo spot. The highest percentage of attack was observed at the end of tillering stage in the presence of two diseases, Septoria and powdery mildew, then a slight decrease was recorded at the heading stage. According to Zahri *et al.* (2014), the

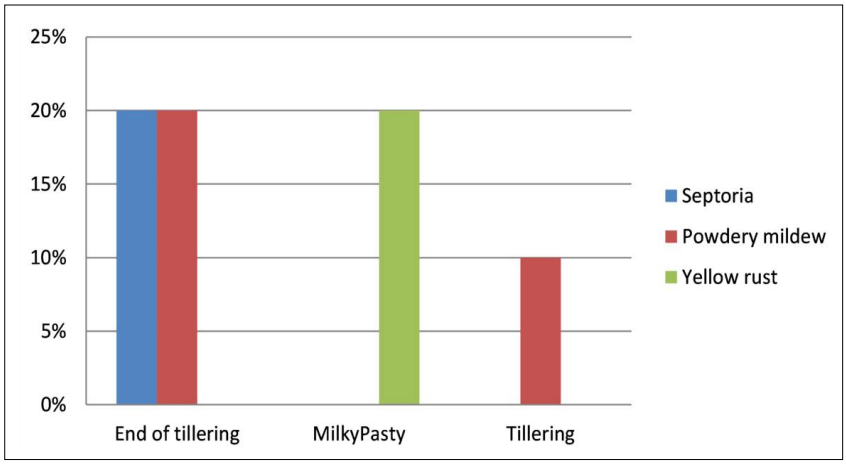

Fig 5: Rates of fungal disease infestations recorded during all stages of wheat development in the Bouira region.

most frequently encountered foliar fungal diseases in soft wheat fields are septoria *Septoria tritici*, *Stagonospora nodorum*, brown rust *Puccinia triticina*, bronze spot *Pyrenophora tritici-repentis*, Drechs anamorph *Drechslera tritici-repentis* and white *Blumeria* (*Erysiphe*) *graminis f.sp. tritici*. In durum wheat fields, the situation was characterized by the predominance of brown rust, bronze spot and septoria. Powdery mildew was less significant. On both wheat species, symptoms of black and yellow rust were not identified. The presence of powdery mildew is observed on both durum and soft with an attack rate of 30% and 20% respectively in soft wheat variety HD1221 and durum wheat variety semito R1. Thus, these two varieties are more or less sensitive to powdery mildew and that the soft wheat variety HD 1221 is more sensitive compared to the durum wheat variety Semito. The halo spot is observed with lower infestation rates on the varieties HD 1221 and Semito G4 respectively with attack percentages of 10% and 15%. These results are similar to those of Sayoud *et al.* (1999), whose study carried out during the 2017/2018 agricultural campaign and to highlight the fungal diseases developed in the constantine region and their relationship with the climatic conditions of the region, the cirta, GTA dur and Semito varieties were all affected by Powdery Mildew with different severity rates. The development of the disease is optimal between 15 and 22°C. In the Bouira region, three fungal diseases are identified, powdery mildew, Septoria, yellow rust, in durum and soft wheat plots, the dominance of powdery mildew is noted in plots where the infestation rates for powdery mildew are equal to 20% on durum wheat variety Semito and 10% on durum wheat variety core. Yellow rust and Septoria are observed only on durum wheat variety Semito and soft wheat variety maouna. According to Zahri *et al.* (2014) in durum wheat fields, the situation was characterized by the predominance of brown rust (79.0%) and septoria (45.8%). Powdery mildew was the least prevalent (14.2%) on soft wheat and 11.4% on durum wheat and the least severe (8.0%) due to its late appearance in the wheat cycle. No symptoms of yellow or black rust were revealed. These different results observed in the two regions are not only caused by the sensitivity factor or the resistance of the varieties studied, but also by the influence of climatic conditions. Indeed, in the Tizi-ouzou region, climatic data reveal that the period between February and April was humid, precipitation reached 246.6 mm in April and 309.4 mm in May, temperatures vary between 16 and 21.6°C. For Bouira, precipitation reached 185.7mm in April and 201.9 mm in May, temperatures varied between 14.5°C and 20.6°C unlike the temperatures and precipitation recorded during previous years in this region where annual precipitation equals 374.4 mm. This explains the appearance of diseases during the end of tillering and heading stages for Tizi-ouzou and the tilleringend of tillering and milky-pasty stages for Bouira. Despite the various fungal treatments applied, the diseases are present with a strong attack (25%), which explains why the application of the product was done at the advanced stage of the disease in which the climatic conditions are favorable for the development of the latter. Ezzahiri (2001) states that wheat can be attacked by many diseases at different stages of its development and that these attacks can cause significant losses when the varieties are sensitive and the environmental conditions are favorable. Indeed, climatic factors, particularly humidity and temperature, play a key role in the contamination processes since they will condition the germination and infection of the fungus. According to Abdel-Kader *et al.* (2020) wheat plants are infected with many diseases during the growth stages and storage periods causing quantitative and qualitative reduction in plant stand, produced yield and stored grains. Anita Rani *et al.* (2025) reports that one of the primary factors that reduce agricultural productivity is plant diseases.

CONCLUSION

The results obtained clearly show differences in the period of appearance of diseases and the rates of infestations from one variety to another according to the vegetative stage on the one hand and from one bioclimatic stage to another on the other hand. The minimum temperatures recorded in the sub-humid are lower than those of the semi-arid. Also, the precipitations recorded in spring in the Bouira region are less important compared to those recorded in the Tizi-ouzou region which caused a shift in the vegetative stages in the semi-arid region. The appearance of diseases is conditioned by two very important factors: temperature and humidity. The treatment schedule must be established for each region separately taking into account the dates of appearance of the diseases.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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