Remittances Review
June, 2023
Volume: 8, No: 4, pp. 749-758
ISSN: 2059-6588 (Print) | ISSN 2059-6596 (Online)
remittancesreview.com

Received: 28 November 2022 Accepted: 28 March, 2023
DOI: https://doi.org/10.33182/rr.v8i4.52

Climatic Conditions of Rust Disease Condition on Agricultural Crops in Diyala Governorate

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Abstract

The appropriate climatic conditions for the spread of rust disease on agricultural crops were studied in Diyala Governorate. The study aims to clarify the appropriate climatic conditions for the spread of rust disease on agricultural crops in the governorate, as it is one of the factors affecting agricultural crops that pose a threat to living organisms, and therefore it serves as a protector for the environment from the risk of deterioration and pollution. The study relied on meteorological data and information and the Ministry of Agriculture in Diyala Governorate. The study concluded that The appropriate months according to the requirements of rust disease for the maximum temperature of Al-Khalis station and Al-Khanaqin station in the study area after June, July, August and September are moderately suitable, with a percentage of (22.5) degrees.The months of January, May and September are after average suitability, with a percentage of (4.0) degrees. February, March, April, May, October, November and December are not suitable, with a percentage of (5.0) degrees. The degree of suitability varies, as the degree of excellent suitability was recorded at (25) C, limited according to the requirements of rust disease, while the average degree was (20-35) C. As for the unsuitable, it was recorded as less than (19) and more than (36) C.

Keywords: *climatic conditions, agricultural pests, agricultural crop*

Introduction

The climate with its various elements is at the forefront of the factors affecting agricultural production. Each crop has certain climatic conditions that respond to it. If these conditions are available, it gives the best yield, as the climate plays a prominent role in influencing the stages of crop growth, starting from the germination stage until the crop harvest stage. Temperature, rain, relative humidity, and wind have an effect on agricultural crops, and this does not affect the spatial distribution of agricultural crops, but rather affects the quantity and quality of crops and the extent of their exposure to agricultural pests. Providing appropriate environmental conditions for crop cultivation is the best way to succeed in agriculture in any geographical area. It is well known that each plant or agricultural crop has specific climatic requirements. These requirements are needed by the plant at every stage of its growth. Therefore, the crop does not give economic production unless its climatic requirements are met. This does not mean that the dry climate does not have agriculture, as crops that are related to it are grown in Diyala Governorate. Rust is a fungal disease that affects some agricultural crops such as wheat and rye. Rust has different strains specific to different species, so the strain that infects Posaceae crops. Rust diseases are diseases of wide spread and economic importance on grain crops all over the world. There are three distinct diseases that are different from each other: leaf rust, striped/yellow rust, and stem rust affecting wheat and barley. The fungi that cause these diseases are known to rapidly increase and overcome resistance in wheat and barley cultivars. Agricultural crops in the study area are exposed to several endemic diseases that cause great damage to them, due to the

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influence of a group of climatic elements whose role is highlighted in the spread and emergence of diseases and insects in the study area, so this research will be studied in terms of their types and how they spread in the study area and what They are the climatic requirements that help in their emergence as well as identifying the most important endemic diseases and pests in the study area, including rust disease.

Study Problem

The research problem is one of the most important elements of scientific research. The research is only a problem that the researcher seeks to solve. The research problem is the main problem: What is the extent of the impact of climatic conditions on the spread of rust disease in Diyala Governorate? What are the most favorable conditions for its spread? Fourth: The study hypothesis: The research hypothesis is the second step after the problem, in order to give initial solutions to a proposal for the study, so the main research hypothesis came as follows: The climatic conditions have an impact on the severity and spread of rust disease in Diyala Governorate. As the climatic elements had a prominent role in the increase and spread of this disease in Diyala Governorate.

Study Objective

The main objective of this research is to analyze the impact of climatic elements on the emergence and spread of rust disease in Diyala Governorate. In order to complete this objective, the main objective was divided into secondary objectives to facilitate the analysis process and reach the answer. The research aims first to analyze the fluctuation and trend in the climatic elements within the stations of the study area to reveal the nature of fluctuations and climatic changes in them, and then analyze the geographical distribution of rust disease that affects agricultural crops. temporally and spatially within the study area.

The Importance and Justification of the Study

Rust is one of the most dangerous diseases that affect agricultural crops in the study area, especially wheat, so it poses a danger to various living organisms on the surface of the earth, including humans, plants and animals. From this seriousness came the importance and justification of the study for the appropriate climatic conditions for the spread of rust disease on agricultural crops in order to know the most important results that the researcher can reach in order to detect the seriousness of the disease in an accurate scientific manner.

The Boundaries of The Study Area

1- Administrative borders

The boundaries of the study area are represented by (Diyala Governorate), which is located in the central part of eastern Iraq, and this is shown in map (1). It is bordered by four governorates, which are in the north-east, Sulaymaniyah Governorate, Salah Al-Din Governorate in the west and northwest, Baghdad Governorate in the west and south-west, and Wasit Governorate in the south. As for the eastern side, it is represented by the international borders between Iraq and Iran. During the study period, it reached (19047) km^2 in 1977, while it became (17823) km^2 in 1987. After making the administrative changes that took place in the governorate, its area became (17685) km^2.

2- Spatial Boundaries

The study area is located between two latitudes (35° 6-00 - 33° 33-00) north and longitudes (45° 56-00 - 44° 22-00) eastward. Six districts join the province administratively, namely (Baquba, Muqdadiya, Khalis, Khanaqin, Baladruz, Kifri). See map (1).

3-Temporal Limits

The appropriate climatic conditions for rust disease were studied for a period of (11) years, which is considered a microclimatic cycle (2009-2020). Khanaqin station was relied upon to obtain the monthly averages of temperatures.

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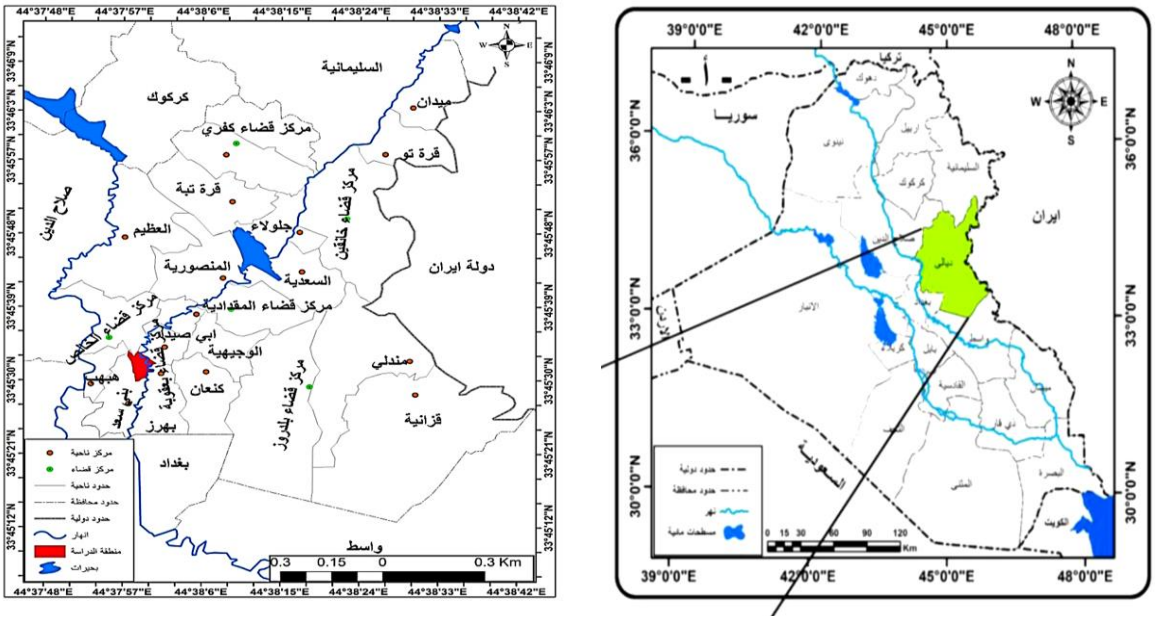
Map (1) The location map of the study area.



Republic of Iraq, Ministry of Agriculture, the General Authority for Survey, topographic map (ArcMap 10.4.1) [1].

Rust Disease That Affects Plants in the Study Area

A-Rust Disease

These diseases cause an increase in respiration and transpiration and reduce the photosynthesis process, and affect plant hardiness, root growth and grain formation. The pathogens responsible for rust diseases in Al-Fasah are characterized by the length of their life cycle and their need for two types of plant hosts to complete the life cycle, and five types of germs are formed on them (Basidia, with the name Acidic, Eurynic-Tele) in addition to the presence of the mutual host on which the rust fungus completes the life cycle. Rust fungi can also grow It infects some grassy weeds (secondary hosts) and kills the diseased pathogen during the period between agricultural seasons. Rust diseases differ among themselves in the fungus that causes the disease, the location and shape of the infection, and the climatic conditions for each of them.

The most important rust diseases prevalent in the study area are:

A-Orange Rust

This disease also Leaf rust, dwarf rust, or brown rust, and it spreads in all wheat-producing countries in which high air humidity is available. It also spreads in the northern, central, and southern regions of Iraq, including the study area, and the incidence of it varies from year to year, depending on due to the amount of rain falling and other weather conditions, and its risk increases if it occurs early and continuously during the growing season, as this leads to a reduction in grain size and a decrease in total production, and the infection of the disease increases when the crop is late in ripening in spring [2]Temperature is one of the important factors in the development of rust disease, and that The optimum temperature for the growth of the Precondita fungus on leafy sections of the wheat plant was 25 °C, and the growth of the aforementioned fungus depends on a temperature of 20 °C. Wheat fields in the study area in the month of March, whose

average temperature for the year 2016 was (28.3), which is suitable for fungus activity, and the prevalence of this disease was within (10%) [3]. Rust is one of the diseases that affect wheat in the study area and leads to large losses of (1-20%). It is in the form of teletic spores on the wheat plant. These germs grow spontaneously and are a source of primary infection. The infection rate varies in the study area depending on the environmental conditions suitable for the spread of wheat. The disease is (20-25˚C) and the spores spread by the wind [4], and the temperature is the important factor in the activity of the disease and that the ideal temperature for the growth of the disease is (25˚C) and the growth of the fungus stops when the temperature is less than (20˚C) [5]. Wheat rust is one of the most widespread diseases in the world, and Gradd (1977) is the first to describe yellow rust disease, and the disease is considered the main cause of epidemic on the rye crop in Sweden [6]and noted the presence of the disease in about 60 countries and is found in all continents of the world except Antarctica [7], and this disease is one of the most affecting diseases on wheat and causes losses of up to 70% [8]. The disease appears through interactions within the infected plant, and the interaction varies according to the genetic makeup of the family and the strain of the disease, as well as the role of environmental conditions that help speed up or slow down the spread of the disease [9].

Image (1): Rust Disease [1].

B- Brown Rust in Wheat (Leaf Rust)

The disease spreads in places where high humidity is available. The disease is suitable for environmental conditions that are colder than those suitable for infection with stem rust [10]. Its spread may be due to the climatic conditions represented by the temperature between precipitation, cold weather, and high humidity starting from May, as this affected the product because it is more sensitive to disease and their life cycle is long, unlike other varieties, where we noticed the formation of circular or oval pustules of orange or brown color. Reddish and small in size with a dusty and explosive composition that is scattered and gathered in an elongated manner on the surface of the leaf [11].

Symptoms of Rust Disease

The appearance of the uremic phase usually begins in early March with the formation of round or oval pustules with an orange color tending to Yellow. Pustules are spread irregularly on the affected plant parts. These pustules usually abound on the leaf blades and leaf sheaths, especially the lower ones. They are found

to a lesser extent on the floral parts. Telepustules form near the end of the season. They are similar to ureidic pustules in shape and distribution, except that their color is brownish-brown. to blackness, and the telangiectatic pustules remain covered with the skin of the host without bursting, which gives them that smooth, shiny texture [12].

Image (2): Symptoms of brown rust on wheat leaves [1].

Resistance

Cultivation of wheat varieties that are resistant to the disease, as there are many physiological strains of the fungus that causes the disease. Research also indicates the development of new types of winter wheat with compound resistance to leaf rust, stem rust, and powdery mildew. Follow agricultural processes that reduce the degree of infection, such as not planting in low-lying areas with poor drainage. Also, do not add nitrogen fertilizers in excess [13].

C- Yellow Rust

It was noticed that it spread in the farms of the study area, where it appeared at the beginning of April, and the reason for its appearance may be due to the temperature recorded between (5-15 C°) [14], as this period witnessed cold weather, rain and high humidity. Which helped to spread it profusely and very quickly due to the climatic conditions suitable for its spread, which greatly affected the crop. We noticed the emergence of several symptoms at the leaf level, which form several spore pustules in the form of a bright yellow powder in the form of long lines parallel to the leaf axis distributed longitudinally [15].

Effect of Climatic Elements on Rust Disease in The Study Area

First: Temperature:

Insects vary in their ability to withstand temperatures. Lepismodes inquilinus insect. Most insects die when exposed to a temperature between 52-55 C° for a period of (3-4) hours. Insects generally have three thermal stages [16], which are:

A - Thermal activity stage:

It is located in most cases between 15-27 m, during which the insect activity increases, and within this stage there is a temperature temperature at which the insect activity is at its peak in terms of the speed of growth and the rate of eggs that are hatched. You set it, known as the optimum temperature [18].

B - The thermal dormancy stage:

its ranges are located above the thermal activity stage, where the insect's activity decreases significantly, which forces it to stop feeding and resort to misleading places for the purpose of hibernation, which is known as Chinese aestivation, which is a temporary hibernation, as once the unsuitable conditions disappear, the insect resumes its activity again [19].

C - Thermal death stage: It is located above the stage of thermal stillness, where the insect's activity stops

and dies sooner or later even if the temperature then drops below this degree. And if temperatures continue to rise, the insect will die within a very short period, as a result of the harmful effects of high temperatures on the physiological characteristics of the membranes, which can change the nature of the work of important enzymes in metabolic processes [20]. Insects suffer from various consequences when temperatures fall below their stage of growth and activity, and they become paralyzed at temperatures higher than freezing, especially insects that are not used to wintering. In general, they are sensitive to freezing, and the nature of damage to sensitive species is unknown. It is possible for ice crystals to rupture body cells. Mechanic 74 Launch 133 The formation of ice crystals causes an imbalance in the concentration of blood chemicals and in cell fluids [21].

Humidity

Although the direct physiological effect of moisture is less than the effect of heat, it may cause food that supplies the insect with the water needed for its metabolic processes. However, the effect of moisture on the activity and distribution of insects in nature remains an important factor. In order for the insect to survive, it must maintain its German content as long as the internal water The insect is usually affected by external weather factors. Insects are somewhat resistant to desiccation due to the fact that their body wall contains a hard cuticle layer that includes a water-impermeable layer at its surface [22]. The waxy layer, as well as the presence of devices to close the respiratory stomata helps a lot in regulating the loss of moisture from the bronchial system, as well as the ability of the insect to re-absorb water resulting from metabolic processes. Insects vary in their tolerance of moisture, which is usually characterized by their youth. Aphids, leafhoppers, and mosquitoes prefer moist places and die easily in places where the relative humidity is low. Also, stored grain pests of mites and beetles die if the moisture content of the grain falls below 7.3, while we find that some stages of insects exaggerate their tolerance for very high humidity levels. Leaf miners live in places where the relative humidity reaches 100% saturation. In general, most types of insects prefer an atmosphere in which the relative humidity ranges between 70-80% [23]. The combined effect of heat and humidity occurs directly when both are high. In this case, the insect cannot cool its body through the evaporation of water, nor can it get rid of the metabolite water. Therefore, heat build-up occurs as a result of the metabolic processes that lead to its death. In an environment where the temperature is high and the relative humidity is low, the matter will be critical because of the high water content inside the insect's body and its low outside, which results in the risk of continuous loss of water due to evaporation. High humidity may cause the death of insects indirectly, as pathogens such as fungi, bacteria and other microorganisms flourish, resulting in infection and death of large numbers of them, especially their incomplete stages [24].

Sunlight

After light, it is one of the important factors in the life of insects. It is responsible for directing insects in their environment and in the timing of events in their life cycle. The different activities of insects occur during a certain period of the day. Synchronization allows the two sexes to get to know each other for the purpose of mating, as determined. Search for food and escape from enemies or find a suitable place to lay eggs [25]. The daily activity of insects varies according to the species, so if their activity increases during the day, it is called the end of Diurmal activity, such as honey bees, abi minutes, and parasitoids. It is called a nocturnal activity when its activity increases during the night, such as butterflies and predators. But if it is active during dawn or dusk, it is called crepuscular activity, as is the case in most types of minute butterflies that follow the family. The end of activity is called diurnal, such as honey bees, minute and parasitoids. It is called a nocturnal activity when its activity increases during the night, such as butterflies and predators. But if it is active during dawn or dusk, it is called crepuscular activity, as is the case in most species of minute butterflies that follow the family Gracillariidae of the order Lepidoptera [25].

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Table (1) The appropriate climatic conditions for the spread of rust disease in the study area for the period (2009-2020).

Photorequirement for rust disease in the study area												
Rust disease	hours a day(4-6)											
Suitable and unsuitable temperatures (°C) for rust disease in the study area												
appropriate temperature	25											
Inappropriate temperature	20											
The upper, lower and ideal limits of temperature (°C) for rust disease in the study area												
Maximum limit of temperature	35											
Minimum of temperature	20											
Ideal temperature	25											
Percentage of area affected by rust disease in the study area												
Rust disease	70-80%											
Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Disease	100	—	—	—	—	—	—	—	—	—	240	260

By analyzing Table (1), it was found that the affected area varied in the studied period (2009-20202), and it became clear that it reached (100) in 2009, which is less than a year (2019-2020), as it reached (240) and (260) respectively. And the temperature that suits the spread of rust disease in the study area is (25 C°), and if it drops to (20 C) it becomes inappropriate, while the maximum temperature reached (35 C) i.e. in the months of May and June and the minimum (25 C°) and the ideal (20 C°) i.e. in The month of March, and the relative humidity that is suitable for rust disease is (70-80%) 5. Also, rust disease needs approximately (4-6) hours per day. Table (1).

Table (2): The effect of maximum temperature on rust disease in the study area

Months	**Max Temperature (Khalis station)**	**Degree**	**Result**	**Max Temperature (Khanaqin station)**	**Degree**	**Result**
January	15.5	3	Inappropriate	16.2	3	Inappropriate
February	18.6	3	Medium appropriate	18.7	3	Inappropriate
March	23.5	2	Medium appropriate	23.2	2	Medium appropriate
April	29.7	2	Inappropriate	29.9	2	Medium appropriate
Mays	36.2	3	Inappropriate	37.0	3	Inappropriate
June	41.0	3	Inappropriate	42.5	3	Inappropriate
July	34.6	3	Inappropriate	45.2	2	Inappropriate
August	34.6	3	Inappropriate	45.4	3	Inappropriate
September	34.6	3	Medium appropriate	40.7	3	Inappropriate

October	32.9	2	Medium appropriate	34.1	2	Medium appropriate
November	23.6	2	Inappropriate	24.2	2	Medium appropriate
December	17.6	3	Inappropriate	18.1	3	Inappropriate

Table (2) shows that the appropriate months according to the requirements of rust disease for the maximum temperature of Al-Khalis station and Al-Khanaqin station in the study area after June, July, August and September are moderately favorable, with a percentage of (22.5) degrees. Of (4.0) degrees, and after January, February, March, April, May, October, November and December, it is not appropriate, as it reached a percentage of (5.0) degrees.

Table (3) The suitable temperature for rust disease in the study area

NO.	**degree of suitability**	**The limits of suitability according to the requirements of the disease**
	Excellent suitability	25
	average suitability	20-35
	unsuitabile	19 or less is appropriate, 36 or more is not appropriate

From the analysis of Table (3), it was found that the degree of suitability varies, as the degree of excellent suitability was recorded at (25 C°), limited according to the requirements of rust disease, while the average degree was (20-35 C°). As for the inappropriate, it was recorded as less than (19 C°) and more than (36 C°).

Results

1- It appeared that rust disease spreads in places where there are high levels of humidity, and the disease is compatible with more environmental conditions, where the relative humidity ranges between 70-80%.
2- The rust disease appeared through interactions inside the infected plant, and the interaction differed according to the genetic makeup of the family and the strain of the disease, as well as the role of environmental conditions that help accelerate or slow down the spread of rust disease.
3- The study showed that rust disease is one of the diseases that afflict wheat in the study area and leads to large losses amounting to (1-20%) and it is in the form of teletic germs on the wheat plant and these germs grow spontaneously and are a source of primary infection and the infection rate varies in the study area depending on Environmental conditions suitable for the spread of the disease (20-25˚C) and spores spread by wind, temperature is the important factor in disease activity and the ideal temperature for disease growth is (25˚C) and fungus growth stops when the temperature is less than (20˚C)).
4- It was found through the study that climatic changes affect the spread of plant diseases and pests. Studies have shown that increasing temperatures, changing the pattern of humidity and solar radiation lead to an increase in the spread of diseases and plant pests in the region. These atmospheric changes are a contributing factor to the problem world.
5- Diseases and pests affect agricultural production, as plant diseases and pests affected agricultural production in Diyala Governorate, which led to significant economic losses for private farmers. Agricultural productivity significantly increased in areas affected by diseases and pests. Generate the

spread of plant pests and that immune changes may lead to an increase in the spread of endemic plant pests in Diyala Governorate, for example, high temperatures can enhance the activity of ants and harmful insects and increase their spread. This can cause significant crop losses and a negative impact on food security.

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