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CORRELATION BETWEEN CLIMATIC FACTORS AND DYNAMICS OF PATHOGENS AND PESTS: A CASE STUDY IN CABBAGE CROPS

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Abstract

The study analyzes the impact of climatic conditions on the dynamics of diseases and pests in cabbage crop at the Vegetable Research and Development Station Bacău. High temperatures, with a maximum of 35.5°C in mid-summer, favored the development of pests such as Phyllotreta spp. and Plutella xylostella, while the August drought (rainfall of 0.3 mm) increased infestation. In contrast, high humidity in May-June supported the emergence of Brevicoryne brassicae, while heavy rainfall in September (170.4 mm) intensified the spread of fungal diseases, including Xanthomonas campestris. The analysis correlates variations in temperature, humidity and rainfall with the specific dynamics of the main pest species, highlighting the major challenges for phytosanitary control of cabbage crops in the context of climate change. The results provide a basis for improving integrated management strategies adapted to extreme and diversified weather conditions. The study underlines the importance of agro-meteorological monitoring in optimizing crop protection.

Key words*: agro-meteorological monitoring, cabbage pests, climate variability, integrated pest management, NE Region.*

INTRODUCTION

The term 'climate change' refers to long-term changes in temperature, precipitation patterns and other atmospheric conditions on Earth. These changes are driven primarily by human activities such as fossil fuel burning, deforestation and industrial processes, which increase the concentration of greenhouse gases in the atmosphere (Filonchyk et al., 2024). Climatic factors play a very important role in influencing the prevalence and behaviour of pathogens and pests that affect cabbage crops. The relationship between environmental conditions and the health of these crops is complex, and understanding this relationship is essential for the development of effective agricultural practices, especially in the context of climate change. Pathogens and pests are very sensitive to climatic variables such as temperature, humidity and precipitation (Skendžić et al., 2021). These factors can directly affect their life cycles, reproduction rates and survival. For example, temperature fluctuations can influence diapause of insects. Similarly, cold tolerance of insects is significantly affected by environmental temperatures, affecting their ability to infest crops (Muscalu et al., 2020; Subedi et al., 2023). For example, the development and spread of crop diseases are closely linked to climatic conditions (Zhou et al., 2024). A simulation model that integrates crop growth and pathogen development can quantify the direct and indirect effects of climate change on crop diseases. This model helps to understand how changes in temperature and humidity can influence plant disease dynamics (Dumitru et al., 2023). Host-pathogen dynamics are often independent of density, which means that the impact of climate change on temperature- and moisture-related factors is also crucial for predicting the behaviour of pests such as gypsy moth in different regions and climates over time (St. Leger, 2021). Changes in abiotic conditions, such as temperature and moisture, can disrupt the microclimate around plants, affecting soil microbial communities and canopy pathosystems. These changes can lead to significant shifts in disease manifestation, geographical distribution and economic implications, necessitating adaptations in disease management strategies and cropping systems (Lahlali et al., 2024). The spread of invasive alien species is another critical issue influenced by climate change as it poses a substantial threat to global biodiversity and can cause significant economic losses in agriculture, forestry and aquatic ecosystems (Shrestha, 2019; Subedi et al., 2023). In Nepal, for example, the introduction of *Tuta absoluta* in 2016 had serious implications for local agriculture (Shrestha, 2019). Pathogen populations naturally adapt to climate change in both natural and agricultural systems. However, host populations, particularly in agricultural systems, may not adapt as quickly. This can lead to decreased genetic diversity and reduced resistance to pest and disease outbreaks. In agriculture, where genetically uniform crops are grown over large areas, new varieties need to be developed to improve their adaptation to changing climatic conditions (Pangga et al., 2011).

This study was conducted to examine the correlation between variations in temperature, humidity, and rainfall and the dynamic of key pathogens and pests population, highlighting key challenges in phytosanitary control of cabbage crops amid climate change. The findings serve as a foundation for enhancing integrated management strategies tailored to extreme and variable weather conditions. The study, conducted by researchers from the Vegetable Research and Development Station Bacău, emphasizes the critical role of agro-meteorological monitoring in optimizing crop protection.

MATERIALS AND METHODS

Experimental Site and Design

The study was conducted in 2024 from May to September, on a total of 1.85 ha conventional agricultural field at the Vegetable Research and Development Station of Bacău. The research aimed to analyze the correlation between climatic factors and the dynamics of pathogens and pests affecting cabbage crops.

Observations and Data Collection

Observations were made to determine the primary pathogens and pests affecting the cabbage crops. Data collection involved monitoring attack frequency (F %) and attack intensity (I %) every 10 days under natural infestation conditions. Using these parameters, the degree of attack (GA %) was calculated to identify key species and analyze their dynamics in relation to climatic factors.

Climatic Data Monitoring

To evaluate the influence of environmental conditions on pest and pathogen dynamics, climatic parameters were recorded using the iMetos 3.3 weather station installed at the research station. The monitored parameters included temperature, humidity, rainfall, and wind speed. These factors were analyzed in correlation with the specific dynamics of pathogens and pests.

Data Analysis

The collected data were statistically analyzed to determine the relationships between climatic variations and the occurrence and severity of pathogen and pest attacks in cabbage crops. The results provide insights into how weather conditions influence the prevalence and spread of key pest and pathogen species.

This study contributes to a better understanding of the correlation between climatic factors and pest and pathogen dynamics, supporting improved monitoring strategies for sustainable cabbage cultivation.

RESULTS AND DISCUSSIONS

Local climate conditions greatly influence cabbage production, primarily affecting plant growth and the occurrence and development of disease and harmful insects (Červenski et al., 2022).

Meteorological data for the year 2024 recorded at VRDS Bacău, with the iMmetos 3.3 weather station, shows how climate factors evolved over five months, from May to September.

1. Temperature (°C)

Average temperature

The average temperature follows a typical summer trend, rising steadily from May (15.5°C) to July (about 23.4°C), peaking in the second decade of July (27.0°C). After this, the temperature decreases towards September (16.9-17.1°C). The temperature differences reflect seasonal warming, which peaks in midsummer before cooling in early autumn. August in particular is relatively warm (22.5-25°C).

Maximum temperature

In the summer months, maximum temperatures rise sharply, with notable peaks in July (35.5°C), while August also sees high highs (up to 33.5°C). September's maximum temperatures are lower (28°C), indicating the seasonal transition. The warmest period is the second decade of July, with a high of 35.5°C, typical of mid-summer heat waves.

Minimum temperature

Minimum temperatures rise gradually from May to July (7.9°C to 19.1°C), then fall towards September (to 10.3°C). Hot summer nights (July-August) are favorable for vegetative growth, but can also favor the emergence of certain pests and diseases.

2. Relative humidity (%)

Average humidity

The months of May and June had moderate moisture values (approximately 57-72%). July had relatively lower values (approximately 57-64%), which could be due to warmer and drier conditions. By September, moisture increased sharply, particularly in the second decade (83%), indicating higher moisture levels as the weather cools.

Maximum Humidity

Humidity often reached near saturation levels at night or in the early morning hours, as evidenced by consistent highs near or above 90%, particularly in June and September (up to 100%). This suggests periods of high atmospheric humidity, favorable for disease outbreaks.

Minimum humidity

Daytime minimum daytime humidity levels were quite low, especially in July and August (sometimes below 22%), characteristic of dry and scorching summer days. These dry periods can stress plants, especially drought-sensitive plants.

3. Precipitation (mm)

Precipitation showed significant variations over the months:

May: Moderate precipitation (from 9.6 mm to 21.6 mm), which supported vegetative crop growth in early summer.

June: Precipitation fluctuated (from 7.31 mm to 29.25 mm), with a decrease in the third decade, probably causing a short dry spell.

July: Significant rainfall, especially in the second dekad (40.65 mm), which provided the crop water requirements during the hot spell.

August: Dry period, especially in the second dekad, with only 0.3 mm of precipitation, a possible drought.

September: A sharp increase in rainfall in the second dekad (170.4 mm), suggesting heavy rainfall possibly related to seasonal changes, with potential for soil saturation or flooding.

4. Wind speed (m/s)

Wind speed remained generally low during the monitoring period (below 1.5 m/s), with occasional increases in May, July and September. Low wind speeds are typical for the summer months, although slightly higher values in May might suggest moderate winds, which could affect plant transpiration rates.

Analyzing the correlations between average temperature, relative humidity and precipitation in the period May-September 2024 at SCDL Bacău, we can see how these climatic factors influence plant development and the occurrence of pathogens and pests.

- The increase in temperatures and relatively moderate humidity in May, together with gradually increasing precipitation, are favourable for a good development of legume crops. These conditions stimulate vegetative growth (Chowdhury et al., 2021), but can also create a favourable environment for fungal diseases, such as mould or leaf spot (Juroszek et al., 2022), especially in the third decade of May, where temperatures and humidity have increased.
- In June, higher temperatures and more abundant rainfall in the first two decades favor vegetative growth and flowering. High humidity and rainfall in the first two decades can lead to disease outbreaks, especially in sensitive crops such as tomatoes (Panno et al., 2021). Reducing rainfall and humidity in the third decade decreases the risk of fungal diseases, but can increase water stress, influencing the development of non-irrigated plants.
- The month of July brought high temperatures and low relative humidity, which favors rapid

evaporation of soil water and can lead to soil drying without irrigation (Naorem et al., 2023). Rainfall in the second decade (40.65 mm) counterbalanced this effect. Relatively low moisture can reduce the incidence of fungal diseases (Zhou et al., 2024), but drought resistant pests such as mites and/or thrips can occur. High temperatures, coupled with low moisture levels, can accelerate the growth of pests that affect plant leaves and stems.

- August was a severe drought month in the second decade. High temperatures and low humidity create stressful conditions for plants, resulting in reduced yields (Naorem et al., 2023). This drought can be associated with an increase in pests that thrive in dry conditions, such as aphids and mites (Subedi et al., 2023). Rainfall in the third decade (42.8 mm) is welcome for crops, but may be insufficient to fully recover from the effects of drought. Also, these sudden rains may increase the risk of fruit cracking in tomatoes and favor fruit rot.
- September was a month of extreme rainfall in the second decade. Cooler temperatures and high moisture levels created favorable conditions for fungal diseases and root rot, mainly due to excess water in the soil (Lahlali et al., 2024). Heavy rains can also cause erosion or puddling, affecting crops (Naorem et al., 2023). Heavy rainfall, combined with high humidity, are ideal conditions for mold growth (Mieslerová et al., 2022).

High temperatures in July and August, coupled with low humidity, can create a favorable environment for drought-specific pests such as mites and lead to water stress. Variable rainfall and dry spells in August and June can affect plant development and favor certain diseases (Lahlali et al., 2024) or pests (Skendžić et al., 2021), depending on the type of crop. High humidity and heavy rainfall in September can lead to fungal diseases, especially during heavy rainfall.

Analyzing the data on climatic conditions and the presence of diseases and pests in white cabbage crop at SCDL Bacău, we can make the following clarifications:

1. *Aleyrodes proletella* (cabbage whitefly, Figure 1)

Figure 1. Cabbage whitefly (*Aleyrodes proletella*) on cabbage leaf - original photo

Very low occurrence, observed only in June, with a maximum infestation of 2.2% in the first decade, followed by a rapid decline.

Climatic correlation: Cabbage whitefly prefers warm and dry conditions (Holý & Kovaříková, 2024), but its occurrence in June coincides with a relatively humid period (69.31-72.88%) and moderate temperatures (21.2-22.9°C). The low infestation can be explained by the rainfall in this month (up to 29.25 l/mp). Higher humidity reduces whitefly activity, which prefers drier and warmer conditions.

2. *Brevicoryne brassicae* (cabbage aphid, Figure 2)

Figure 2. Cabbage aphid - colony on cabbage leaf - original photo

Maximum infestation (16.3%) occurs in late May and early June, but declines rapidly in July and August, with a slight reappearance in September.
Climatic correlation: Grey plant louse thrives in moderate temperatures, around 15-25°C, and relatively high humidity. May, with average temperatures of 13.9-18.3°C and humidity around 60%, provides ideal conditions for infestation. As temperatures rise in July and August (above 23°C) and humidity decreases, the louse population declines. In September, with falling temperatures and rising humidity (82.97%), it appears again, but at a reduced intensity (below 0.5%).

3. *Phyllotreta atra* and *P. nemorum* (Cabbage flea beetles, Figure 3)

Figure 3. Cabbage flea beetle (*Phyllotreta* sp.) infestation on cabbage leaves - original photo

Constant infestation (Stoleru et al., 2012), with higher values in June (up to 21.2%) and July (up to 32%).
Climatic correlation: Crucifer flea beetles prefer moderate to high temperatures and low humidity, which explains their intense activity in June and July, when mean temperatures ranged between 21.2°C and 27°C and relative humidity was decreasing (57.78-63.86%). Also, the moderate rainfall in these months (up to 40.65 l/mp) did not create sufficiently humid conditions to inhibit the activity of these pests. In August and September, with higher rainfall and high humidity, their population decreases significantly.

4. *Plutella xylostella* (Diamondback moth)

P. xylostella infestation is low, with sporadic occurrences in July and August (less than 0.2%).
Climatic correlation: The cabbage moth prefers warm and dry conditions (Georgescu et al., 2023) and is more active during periods of high temperatures and low precipitation. Minimum infestation in July and August may be associated with high temperatures (up to 27°C) and relatively low humidity. Increased rainfall in the second dekad of August (42.8 l/mp) may have contributed to limiting this infestation.

5. *Xanthomonas campestris* (Black rot, Figure 4)

Figure 4. Black rot on cabbage leaves caused by *Xanthomonas campestris* - original photo

Significant infestation in July (up to 22%) and August (up to 17.1%), decreasing thereafter in September.
Climatic correlation: Blackfly is favored by warm and humid conditions, especially during periods with frequent precipitation and high temperatures. In July and August, high average temperatures (up to 27°C) and moderate precipitation in July (up to 40.65 l/mp) create a favorable environment for the development of the bacterium. Also, lower relative humidity in July (below 65%) and uneven rainfall in August (0.3 l/mp in one decade and 42.8 l/mp in another) may favor the disease. In September, the heavy rainfall in the second decade (170.4 l/mp) may be too extreme for the bacterium to develop, leading to a decrease in infestation.

CONCLUSIONS

In conclusion moderate temperatures and relatively high humidity in May and early June favor the development of gray cabbage looper and whitefly, although whitefly was significantly less present in the crop. Crucifera flea beetles (*Phyllotreta* spp.) are most active in June and July, periods with higher temperatures and lower humidity, suggesting that moderate drought is favorable for them. Their growth is limited by heavy rainfall in August and September. The cabbage moth has a low presence, with limited activity under drier and warmer conditions in July and August. This suggests vulnerability to sudden climatic changes such as sudden increases in rainfall. Black scurf is a significant problem in July and August, when moderate heat and rainfall create a favorable environment for the spread of this bacterial disease. Excessive rainfall in September appears to inhibit further bacterial growth.

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