Research Article

# Understanding the Spread and Impact of *Stemphylium* Leaf Blight in Onion Crops: An Epidemiological Study

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**Abstract** | Onion (*Allium cepa* L.) is an important vegetable crop commonly cultivated throughout Pakistan. It is a good source of vitamins B and C, phosphorus, and potassium. The production of onion is decreasing due to different abiotic and biotic factors. Among the biotic factors, *Stemphylium* leaf blight caused by *Stemphylium vesicarium* is one of the most devastating diseases of onion that prevail worldwide and causes a huge economic loss. In present study, different varieties were screened against the *Stemphylium* leaf blight disease, meteorological variables (temperature, humidity, rainfall, wind speed) were studied in relation to disease development and different chemicals were tested for disease control. The varieties sown in randomized complete block design (RCBD) for screening purpose and were categorized by using disease rating scale. The recorded data was statistically analyzed using ANOVA and the LSD value (p=0.05) was determined. In varieties screening test, among the 7 varieties selected, none was immune response against *Stemphylium* disease. Varieties like Hike showed resistant response, HON-304E moderately resistant, Kaseer and Rosabella showed a moderatly susceptible response, Sultan and Tarzan showed a susceptible response, and Phulkara (Check) showed highly susceptible response in disease development and spread. Meteorological variables showed that disease severity negatively correlated with temperature. Rainfall enhanced disease development, sunlight duration upto 11 hours also significantly positively correlated with the severity of the disease while relative humidity between 65-85% favored disease severity.

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## Introduction

The normal physiology of onion is likely to be interrupted by a number of biotic and abiotic factors that decreases growth, yield and quality of produce (Ratnarajah and Genanachelvam, 2021). Biotic factors including bacterial, fungal, and viral diseases attack the foliage part of the onion and cause rust, smut, white tip, and downy mildew diseases (Dutta *et al*., 2022). These diseases lower the yield and greatly impact production effects market demand. Deteriorated and smelly production is not accepted at any level of household or industry (Herath *et al*., 2021).

Among various bacterial, fungal, nematodal and viral; *Stemphylium* leaf blight (SLB) caused by fungus *Stemphylium vesicarium* is a serious threat to many crops including onion (Leach *et al*., 2020). It was first reported in Egypt and it also affects other crops such as alfalfa, tomato, garlic, and asparagus (Foster *et al*., 2019). The disease is attributed to the usage of poor quality seed that may result in almost 90% yield losses under severe infection and disease is more prevalent in winter season (Hay *et al*., 2019).

Onion plants affected by *Stemphylium* fungus depict mild yellow to brownish water-soaked lesions that turns black with perithecial fruiting body growth with the passage of time (Sharma *et al*., 2020). The production of fruiting bodies along with necrotic area reduces the photosynthetic rate thus causing restricted plant growth due to limited prepared food and energy (Hoepting, 2017). The pathogen creates hurdles in the successful production of bulb and seeds (Dangi *et al*., 2019). The pathogen growth is favored by the presence of high relative humidity i.e. 85% and a lower temperature of 15-25°C (Zaho *et al*., 2021). *Stemphylium* blight disease becomes a major problem for the crop and causes economic losses if early detection and prevention measures are not adopted (Khar *et al*., 2022).

Having the destructive effects on photosynthetic rate; the most widely used method to get rid of SLB disease is the use of fungicides. The chemical control is an efficient and quick way to relief the crop from fungal stresses (Hussein *et al*., 2018). The chemicals such as mancozeb 0.3%, carbendazim, chlorothalonil, copper oxychloride, hexaconazole, and difenoconazole have been used frequently against SLB disease with significant control (Hassan *et al*., 2020). The extensive use of fungicides deposits harmful residues in the onion deteriorating the environment and development of resistance in the pathogen (Khandagale *et al*., 2022). Drawbacks related to the chemical control of SLB and other fungal diseases have raised the need for finding out the suitable environmental factors for disease development with aim to reduce fungicides usage and to opt alternative and environmentally safe management tactics. The present study was planned with the following objectives:

- Evaluation of onion germplasm against *Stemphylium* leaf blight disease
- To find out the role of weather variables on the development of SLB

## Materials and Methods

*Screening of onion varieties against Stemphylium leaf blight under field conditions*

A total 7 lines (Rosabella, Kasser, Hike, Phulkara, HON-304E, Tarzan, Sultan) were sown in randomized complete block design (RCBD) to assess disease resistance against *Stemphylium* leaf blight (SLB) at research area of Vegetable Research Institute (VRI), Ayub Agricultural Research Institute (AARI), Faisalabad, Pakistan. The details of the germplasm is provided in Table 1.

**Table 1:** *Onion germplasm used for screening against SLB disease.*

| Serial No. | Germplasm | Source |
|---|---|---|
| 1. | Rosabella | AARI |
| 2. | Kasser | AARI |
| 3. | Hike | AARI |
| 4. | Phulkara | AARI |
| 5. | HON-304E | AARI |
| 6. | Tarzan | AARI |
| 7. | Sultan | AARI |

*Cultural operations*

The nursery of onion bulbs were sown by maintaining row-to-row (RR) distance of 40 cm and plant-to-plant (PxP) distance of 15 cm. Hilling was employed to till the soil close to their bases on young plants. This aids in the initial weed control process and lessens onion bulb infections brought on by sporangia that are washed from diseased plant leaves into the soil.

*Data recording*

The crop was sown under natural conditions and was

**Table 2:** *Disease rating scale by (Sharma, 1997).*

| Grade | Percentage proportion of diseased plants that are exhibiting symptoms | Reaction |
|---|---|---|
| 0 | No symptoms present on any plants. | Immune |
| 1 | Plants showing symptoms are under 10% of the total. | Resistant (R) |
| 2 | 10% to 20% of the plants exhibit symptoms. | Moderately resistant (MR) |
| 3 | 20 to 40 % of plants exhibit symptoms. | Moderately susceptible (MS) |
| 4 | 40 to 60 % of plants exhibit symptoms. | Susceptible (S) |
| 5 | Almost 60% of plants exhibit symptoms. | Highly Susceptible (HS) |

*Each variety's disease incidence, disease severity was determined using the formula provided by (Kumar et al., 2011).*

subjected to infection of *Stemphylium*; the disease severity data was started to record in all the rows after the appearance of characteristic SLB disease symptoms. The data was recorded weekly and 6 times to find out the disease progression over time. The recorded data was compared with already designed disease rating scale to categorize the germplasm for their resistance potential (Sharma, 1997).

$$\text{Disease severity (\%)} = \text{Average \% leaf area infected / Total leaf area} \times 100$$

$$\text{Disease incidence \%} = \frac{\text{No. infected plants}}{\text{Total no. of plants}} \times 100$$

*Effect of environmental factors on the development of Stemphylium leaf blight*

Environmental information was gathered from weather observatory installed at Plant-Physiology Section, AARI, Faisalabad (Pakistan). The information was based on the environment's minimum and maximum temperatures as well as rainfall, wind speed, and relative humidity. By analyzing and tracking disease severity data weekly, *Stemphylium* leaf blight disease was linked to various environmental conditions. The most favorable circumstances for the growth of *Stemphylium blight* were assessed using regression analysis.

*Statistical analysis*

Data on the *Stemphylium* leaf blight disease was analyzed statistically using SAS software. Means were used to evaluate the data, and the Least Significant Difference LSD test was used to compare values. The correlation was used to compare environmental data with *Stemphylium* leaf blight.

## Results and Discussion

*Response of onion germplasm against Stemphylium leaf blight disease*

In the evaluation of onion germplasm for disease resistance; the variety "Hike" was the most resistant with low disease severity of (7.2%). The result depicts that "Hike" can withstand disease pressure and pathogen infestation as compared to other genotypes among which the variety "HON-304E" moderately resistant with disease severity (15.3%). The remaining varieties among screened germplasm showed a varied resistance potential against *Stemphylium* as, Kaseer with (21.2%) disease severity, and Rosabella (32.1%) were regarded as moderately susceptible. The varieties Sultan and Tarzan were categorized as susceptible with (43%) and (52%) disease severity, respectively. The highest disease severity score was recorded in "Phulkara (Cheek)" that was (64.2%) and placed in the category of highly susceptible (Table 3). It means "Phulkara" has very minute level of resistance potential against the pathogen and maximum growth and yield losses will be observed.

**Table 3:** *Response of onion varieties against Stemphylium leaf blight disease.*

| S. No. | Germplasm | Disease severity % | Reaction/Result |
|---|---|---|---|
| 1 | Hike | 7.2 | Resistant (R) |
| 2 | HON-304E | 15.3 | Moderately Resistant (R) |
| 3 | Kaseer | 21.2 | Moderately Susceptible (MS) |
| 4 | Rosabella | 32 | Moderately Susceptible (MS) |
| 5 | Sultan | 43 | Susceptible (S) |
| 6 | Tarzan | 52 | Susceptible (S) |
| 7 | Phulkara (Check) | 64.1 | Highly Susceptible (HS) |

*Relationship of environmental factors and the severity of disease*

Overall, there was a strong association between air temperature (both maximum and minimum) and the severity of the disease (Table 4). This relationship emphasizes that how variations in temperature affect the dynamics of disease in a significant manner that highlights the impact of weather conditions on disease prediction and management. Disease severity changes with increase and decrease of temperature that signifies the role of temperature in prediction of disease outbreaks. The severity of disease was found to be negatively correlated with air temperature, decreasing when the temperature climbed and increasing when it declined (Figures 1, 2). The pathogen thrives best at low temperature i.e. sporulation and invasion occurs more efficiently while as the temperature begins to increase the conditions become harsh for the pathogen and subsequently disease develops slowly. It had been observed that rain enhances the development of disease, and that disease development was gradual before rain but increased with it (Figure 4). Rain provides suitable conditions for inoculum development and its spread i.e. pathogen proliferates more speedily under rainy conditions as compared to dry environment. Sunlight durations of up to 11 hours also significantly positively correlate with the severity of disease. The severity of the *Stemphylium* leaf blight was found to be strongly associated with relative humidity. Between 65 and 85% relative humidity was recorded (Figure 3). Disease severity increased as relative humidity increased. Disease severity increased along with an increase in relative humidity. There was significantly negative correlation between disease severity and wind velocity (Figure 5).

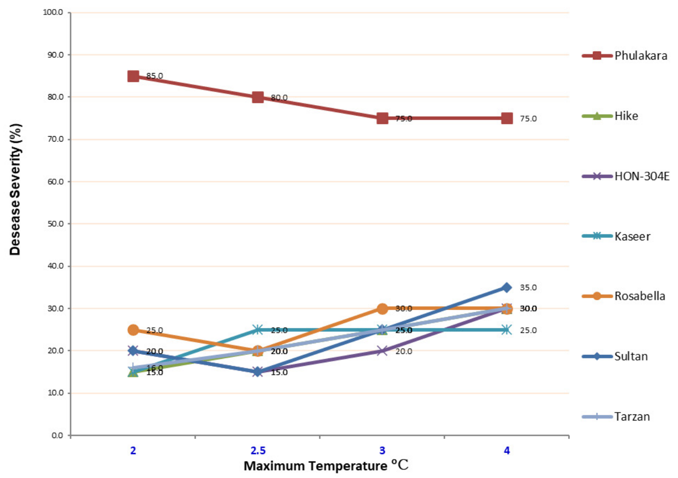


**Figure 1:** *Relationship of maximum temperature with Stemphylium leaf blight disease of onion.*

The overall connection between environmental elements such as maximum temperature, lowest temperature, relative humidity, rain fall, and wind speed across all seven types (Rosabella, Kasser, Hike, Phulkara (check), HON-304E, Tarzan, Sultan) was significant.

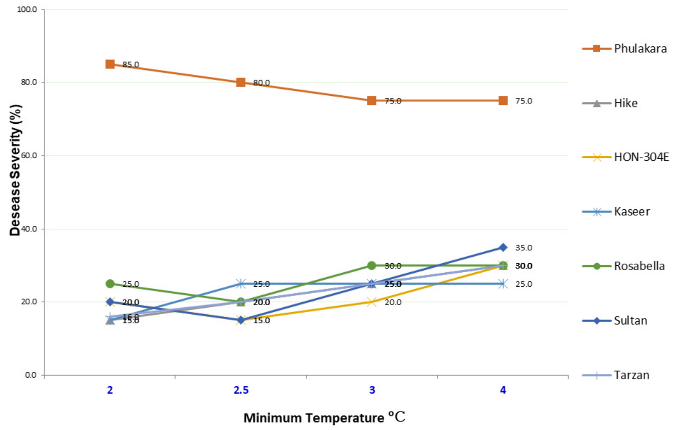


**Figure 2:** *Relationship of minimum temperature with Stemphylium leaf blight disease of onion.*

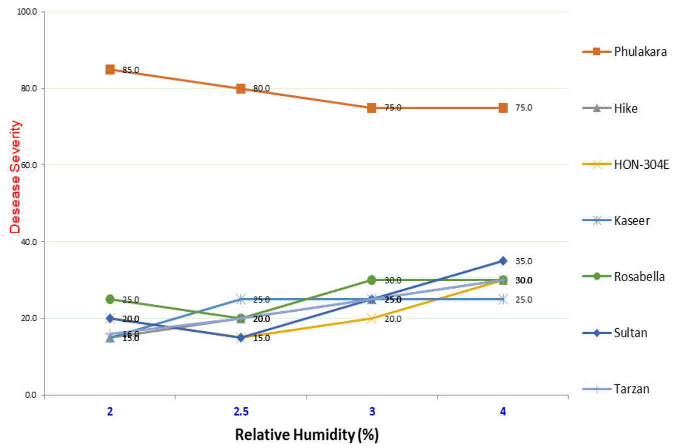


**Figure 3:** *Relationship of relative humidity with Stemphylium leaf blight disease of onion.*

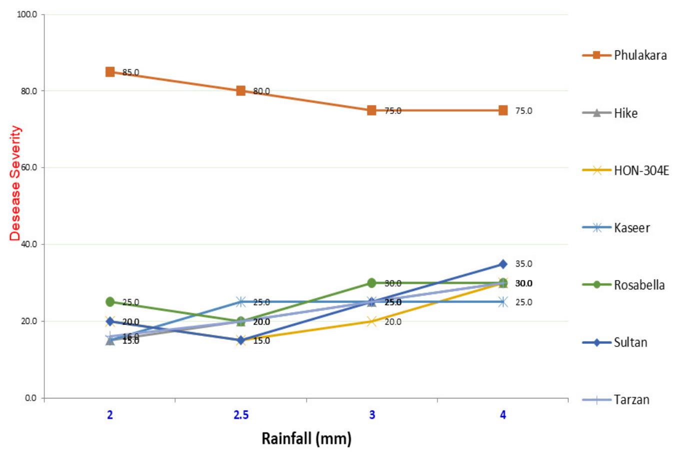


**Figure 4:** *Relationship of rainfall with Stemphylium leaf blight disease of onion.*

The effective production of vegetables in Pakistan, specifically the production of onions, could be threatened by the diseases caused by fungi (Solanki *et al*., 2015). A major disease of onion (*Allium cepa* L.) in Pakistan is *Stemphylium* leaf blight caused by *Stemphylium vesicarium*. This nasty and widespread disease reduces onion yield and quality of bulbs (Arya *et al*., 2017). Moreover, depending on the cultivar being cultivated, damage can be higher in humid regions of the country and in foothill districts. The number of onion leaves per plant infected by the *Stemphylium* leaf blight disease determines the yield losses (Dewangan and Sahu, 2014).

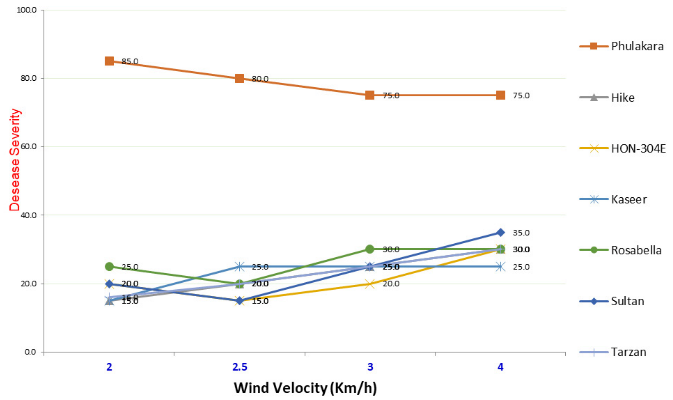


**Figure 5:** *Relationship of wind velocity with Stemphylium leaf blight disease of onion.*

The most durable, risk-free, affordable and simple method of managing plant diseases is through resistance. For instance, to prevent losses brought on by *S. vesicarium*, resistant lines of Welsh onion and garlic might be used (Mishra *et al*., 2009). Earlier research demonstrated that all tested onion lines were sensitive to *Stemphylium* leaf blight (Awan *et al*., 2018). Onion cultivar experiments have been laid in other research at the Muck Crop Research Station at Holland Marsh, Ontario. This finding suggests that there may be variations in how susceptible various onion cultivars are to *Stemphylium* leaf bight (SLB) (McDonald and Kooi, 2014).

In current study, out of 7 genotypes i.e. Hike, HON-304E, Kaseer, Rosabella, Sultan, Phulkara (Cheek), and Tarzan only one variety Hike demonstrated resistance against SLB with disease severity (7.2%). HON-304E expressed a moderately resistant response with 15.3% disease severity; Kaseer and Rosabella demonstrated a moderate susceptible response, with disease severity of 21.2% and 32%, respectively. Moderately susceptible varieties need more attention for timely management in order to avoid from severe losses. The variety "Hike" could be used as an effective disease management tool for integrated disease management programs. This variety can also be considered by the breeders while working on the high yielding and disease resistant varieties. Sultan and Tarzan showed a susceptible response with disease severity of 43% and 52% while Phulkara (Check) revealed a highly susceptible response with a disease severity of 64.1%. These results are in line with those of Yadav (2013) who evaluated 41 onion genotypes for resistance to the disease *Stemphylium* leaf blight in 2 cropping seasons. None of the entries exhibited a resistant (R) or moderately resistant (MR) response to the pathogen while 21 onion varieties demonstrated a susceptible (S), and 2 showed highly susceptible (HS) responses. Host resistance is the most efficient technique for preventing illnesses

**Table 4:** *Environmental factors and their relation with the onion varieties against Stemphylium leaf blight disease development.*

| | | Maximum temperature (°C) | Minimum temperature (°C) | Relative humidity | Rainfall (mm) | Wind speed (Km/h) |
|---|---|---|---|---|---|---|
| V1 | Correlation | -0.694 | -0.794* | 0.92** | 0.859* | -0.372 |
| | Prob. | 0.193 | 0.108 | 0.027 | 0.062 | 0.537 |
| V2 | Correlation | -0.732 | -0.824* | 0.94** | 0.886* | -0.36* |
| | Prob. | 0.16 | 0.086 | 0.017 | 0.045 | 0.552 |
| V3 | Correlation | -0.875* | -0.931** | 0.99** | 0.957** | -0.189 |
| | Prob. | 0.052 | 0.022 | 0.001 | 0.011 | 0.761 |
| V4 | Correlation | -0.785* | -0.869* | 0.959** | 0.906** | -0.268 |
| | Prob. | 0.116 | 0.056 | 0.01 | 0.034 | 0.663 |
| V5 | Correlation | -0.574 | -0.701 | 0.838* | 0.754* | -0.385 |
| | Prob. | 0.312 | 0.187 | 0.076 | 0.141 | 0.522 |
| V6 | Correlation | -0.475 | -0.612 | 0.767* | 0.672 | -0.401 |
| | Prob. | 0.418 | 0.272 | 0.13 | 0.214 | 0.503 |
| V7 | Correlation | -0.509 | -0.663 | 0.753* | 0.606 | -0.155 |
| | Prob. | 0.381 | 0.223 | 0.168 | 0.279 | 0.803 |

***=Highly Significant; *= Significant; α=0.05* that cause major crop losses, requiring little effort to implement by altering existing cultural norms. Most farmers struggle because they lack the tools they need to manage or control the disease. To assist them and aid them in lowering crop loss, it is necessary to transfer the resistance in their farmed crops (Santra *et al.*, 2017). Screening techniques have been employed to introduce resistant cultivars to control the disease. This is the most efficient way to provide crop resilience and control a variety of diseases (Dangi *et al.*, 2018).

The onset of a disease, its severity and damage caused by its susceptible host and virulent pathogen are the basic elements but, the third and most important factor for disease development is favorable environment. The environmental variables i.e. rainfall and maximum and minimum temperature, relative humidity and wind speed have a significant impact on the onset and severity of infection caused by a pathogen (Bruce *et al.*, 2021). According to the findings of recent studies, disease severity of SLB rose between 14 to 52% at temperatures between 10-25 °C and 65 to 80% relative humidity. The effects of these environmental conditions were seen in this experiment. Seven onion cultivars (Hike, HON-304E, Kaseer, Rosabella, Sultan, Phulkara (Check), and Tarzan) were found to have a substantial link between the *Stemphylium* leaf blight disease and the overall maximum, minimum, wind, relative humidity, and rain fall. These findings are almost similar with those of demonstrated earlier by many researchers who demonstrated that the optimal environment for the growth of pseudothecia of *S. vesicarium* is on onion leaf waste. Low temperatures (5-10 °C) and a humid environment are ideal for the development of pseudothecia. Nevertheless, temperatures between 15-20 °C cause early breakdown of pseudothecia whereas relative humidity levels over 96% prevent pseudothecia from forming. Under field conditions, there are more lesions due to longer leaf wetness periods and rising temperatures while spring and autumn have seen higher rates of *Stemphylium blight* than summer (Stricker *et al.*, 2021). *S. vesicarium* pathogen in onion crops causes disease when the weather is damp i.e. environment with a good temperature, humidity, and light. Fog, wind speed, rainfall totals, and other factors have all been found to have a close correlation with the blight-causing bacteria and the diseases (Zapata-Sarmiento *et al.*, 2020).

The rate of infection decreases as the length of the wetness period is shortened. Although *Alternaria porri* and, which produce purple leaf blotch and *Stemphylium leaf blotch*, respectively, these infections often inhabit lesions that develop in the field (Bruce *et al.*, 2021). The ideal temperature for *Stemphylium vesicarium* pathogen growth is 18 to 22°C, however typically, 8.5 to 26°C is good for spore production (Bagchi *et al.*, 2020). The best conditions for the abundant development of sporangia are low air speed and sufficient humidity (90-100% RH). However, many sporangia can also be formed when air speed is high and relative humidity reaches 100%. High air humidity levels promote the production of spores that are close to the water's surface. Night time fits for more sporangia production when temperature and moisture level in the air become favorable for sporulation formation. Daylight during the daytime has a function in inhibiting sporulation in fields. The blue light produces strong inhibitory circumstances when its intensity is low (peak 450 nm), and the level of inhibition increases as temperature rises from 10 to 25 °C (Chandel *et al.*, 2020).

## Conclusions and Recommendations

The article highlights the importance of environment on SLB disease development and its sustainable management through resistant source. The study concludes that "Hike" the most resistant cultivar against SLB disease that can be recommended to farming community for cultivation. SLB disease was progression was exacerbated at low temperature and high humidity. These findings underline the intricate interaction between environmental conditions and genetic resistance for the management of the disease. It is recommended for the researchers to incorporate resistant varieties in breeding programs for high yielding genotypes with good quality traits. It is advisable for the farmers to sow crop in a well-drained and leveled soil along with maintenance of proper spacing to minimize relative humidity.

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## Novelty Statement

The study consisting of *Stemphylium* disease development in relation to meterological variables and its management through resistance potential of the germplasm has not been conducted before. The combined study of SLB disease development with environment and varietal assessment is a novel approach for disease management.

## Author's Contribution

**Muhammad Ahmad:** Conceived idea and conducted research.
**Safdar Ali:** Supervised research and prepared research plan.
**Amer Habib:** Proof read the manuscript.
**Muhammad Usman Ghani:** Statistical analysis.
**Humaira Kalsoom:** Literature review.
**Yasir Iftikhar:** Helped in data recording
**Muhammad Ahmad Zeshan:** Edited the manuscript and helped in write up.

*Conflict of interest*
The authors have declared no conflict of interest.

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