Biochemical studies, Impact of weather circumstances and chemical salts against *Erysiphe cichoracearum DC*, incitant of okra powdery mildew

Abstract

One of the major vegetable crops, Okra, is a member of the Malvaceae family. Among the illnesses, one of the most dangerous fungal diseases that severely reduces yield is powdery mildew, which is brought on by Erysiphe cichoracearum DC. During meteorological weeks 49, 2, and 3, the projected and observed PDI values were nearly equal. Between the 52nd and 1st week, the maximum apparent rate of infection (r) of 0.0758 was recorded; this value was comparable to the "r" value between the 3rd and 4th week. The crop is sensitive to powdery mildew at stage 60 DAS, with a maximum PDI of 64.65%. This is because nutrients are translocated from the source to the sink in later stages of the plant's life, rendering it susceptible. When the amount of chlorophyll in various disease-grade leaves is estimated, it is found that leaves with mildewed 0-scale content have larger amounts of chlorophyll "a," chlorophyll "b," and total chlorophyll, at 0.230, 0.083, and 0.327 mg/g, respectively, while leaves with mildewed 5-scale content have the lowest amounts.

Keywords: *Abelmoschus esculentus, Erysiphe cichoracearum* DC, Chlorophyll, Powdery mildew

Introduction

One of the major vegetable crops, okra (*Abelmoschus esculentus* (L.) Moench) is sometimes referred to as lady's finger or bhendi in India. It is a member of the Malvaceae family and thrives in temperatures that are somewhat warmer. Because of this, it is grown all over the world in milder temperate zones as well as tropical and subtropical nations. Although okra is native to Africa, it is highly valued as a vegetable in India. It is the most well regarded tropical vegetable.

India is home to okra cultivation, which is a lucrative vegetable crop valued mostly for its delicate young fruits. Pods can be eaten fresh, boiled, pickled, or mixed into salads. Okra cooks in moisture to produce a sticky juice that thickens soups and stews. Due to its high nutritional content, okra is utilized in underdeveloped nations to reduce malnutrition and improve food security. 7.46 g of carbs, 0.19 g of fat, 1.9 g of protein, 82 mg of calcium, 57 mg of magnesium, 61 mg of phosphorous, 299 mg of potassium, and 23 mg of vitamin C are found in every 100 g of okra. Minerals like iodine, magnesium, potassium, vitamin A, and vitamin B are also abundant in mature bhendi fruits (Aykroud, 1963). Okra seeds contain 18 to 20 per cent of crude protein (Berry *et al*., 1988).

Okra is cultivated on 1.14 million hectares worldwide, yielding 7896.26 MT of production and 6.90 tonnes/ha of productivity. It is grown on 0.534 million hectares of land in India, with an annual production of 6,371.00 MT and a productivity of 13 tonnes/ha. Gujarat is the top producer with 921.72 tonnes (15.17 percent of overall production), followed by West Bengal (15.06 percent of total output) with 914.86 tonnes. Okra is grown on 10,910 hectares in Karnataka, where it yields 98.91 MT and 11.6 tonnes/ha of productivity. Okra is the vegetable that generates the most revenue from fresh vegetable exports, followed by onions. (Kumar and Reddy, 2015).

Despite its significance, bhendi's productivity and production are limited by a host of diseases brought on by nematodes, bacteria, viruses, fungus, and abiotic stressors. *Fusarium* wilt, cercospora leaf spot, and powdery mildew are the most common fungal infections. *Erysiphe cichoracearum* DC.'s powdery mildew, which causes severe defoliation and a reduction in photosynthesis, is a serious hindrance to the production of bhendi in India, with yield losses ranging from 17 to 86.6 percent (Sridhar et al., 1989). Almost all seasons are affected by the disease, which lowers yield and ultimately results in significant financial losses. (Lande *et al*., 1977).

The disease has been documented to occur in India in the following states: Himachal Pradesh (Raj et al., 1992), Delhi (Prabhu et al., 1971), Karnataka (Sohi and Sokhi, 1976), and Maharashtra (Bharath., 2023). The first signs of a disease on leaves are tiny, white, discolored spots on the upper surface of older leaves, which later spread to younger leaves and eventually cover the entire plant. In extreme situations, the petiole and stem become infected as well and experience necrosis, which causes the leaves to dry out and wither (Saharan et al., 2019).In 2013, a major epidemic of powdery mildew on bhendi was discovered in the Gulbarga area of North Eastern Karnataka, indicating that the disease had reached an economic significance in the state. (Bachihal *et al*., 2014). Systematic studies on the survey and surveillance of powdery mildew occurrences are scarce. To determine the impact of variables like temperature, relative humidity, rainfall, and wind speed on the onset, progression, and spread of powdery mildew illness, research on the development of powdery mildew in connection to environmental factors is crucial. There is insufficient data on the effectiveness of various bio agents, fungicides, and chemical salts against bhendi powdery mildew. Therefore, it is necessary to assess various bio agents, fungicides, and chemical salts against *Erysiphe cichoracearum* DC. in vitro in order to determine their effectiveness in managing the powdery mildew disease and to develop good management strategies to lessen the disease's impact in bhendi.

MATERIALS AND METHODS

Standardization of inoculation technique

Fungal spores collected from bhendi were inoculated to the healthy plants of bhendi under green house condition by following different techniques as follows:

a) Spraying aqueous conidial suspension
b) Swabbing conidial suspension with cotton
c) Making injuries and inoculating
d) Shaking twigs of infected leaves over plants
e) Dusting conidia using camel hairbrush
f) Touching leaves of test plants with infected leaves full of conidia

The best technique was used for proving the pathogenicity

Susceptible stage of crop

To determine the crop's susceptibility to *E. cichoracearum* infection in a greenhouse setting, an experiment was carried out. The seeding was done in pots at intervals of ten days, and it was done three times. The inoculation process involved creating a conidial suspension and evenly spraying it on the crop across all age groups when the first sowed crop was 80 days old. After 15 days, observations were made using a 0–5 scale.

Biochemical studies

Estimation of chlorophyll content

A solution of acetone and water was used to extract chlorophyll, at a ratio of 80% to 20% (v/v). Using a pestle and mortar for two minutes, 0.5 g of bhendi tissue for six distinct disease scales was homogenized with 25 ml of acetone solution 80%. Whatman No. 1 filter paper was used for the filter, and the filtrate was then transferred to a 100 ml volumetric flask that was completely filled with an 80% acetone solution and covered with aluminum foil to prevent chlorophyll from oxidizing in the light. In a spectrophotometer, absorption was recorded at 663 and 645 nm. The amount of chlorophyll (a, b, and total) in milligrams per gram of fresh weight was reported. Using Arnon's formula, the amounts of chlorophyll a, b, and total were determined. (1949).

Chlorophyll a (mg/g) = $(12.7\ A_{663} - 2.69\ A_{645}) \times X/1000 \times n$

Chlorophyll b (mg/g) = $(22.9\ A_{645} - 4.68\ A_{663}) \times X/1000 \times n$

Total chlorophyll (mg/g) = $(20.2\ A_{645} + 8.02\ A_{663}) \times X/1000 \times n$

Where;

A_{645} = Absorbance of the extract at 645 nm

A_{663} = Absorbance of the extract at 663 nm

X = Total volume of the filtrate

n = Tissue weight

To study the influence of weather parameters on bhendi powdery mildew pathogen

Prediction model for powdery mildew

The current research was conducted at the College of Agriculture, Bengaluru during Rabi 2020–21, on the vulnerable variety Arka Anamika, with the exception of managing powdery mildew disease, in order to establish a prediction model for the disease. Using a straightforward regression equation, the development of powdery mildew disease was investigated in connection to the severity of prior cases.The observations on powdery mildew disease severity was recorded on 10 randomly selected plants by following 0-5 scale at an interval of seven days starting from the day of planting till the end of the crop. Per cent Disease Index (PDI) was calculated as described by Wheeler (1969). Later, disease was predicted, using simple regression equation. This was found out based on onset of disease and its further development.

Simple regression equation will give the association between disease development with week of onset of disease and it was found to be in the order of.

$$\hat{Y} = a + bX$$

Where,

$\hat{Y}$ = Predicted PDI

X = Previous week PDI

b = Co-efficient (slope)

a = Constant

$$b = \frac{1/n \, \Sigma \, xy - xy}{1/n \, \Sigma \, x^2 - y^2}$$

$$a = \hat{Y} - bx$$

R value can be calculated by

$$R = \frac{\Sigma xy}{\sqrt{(\Sigma \, x)^2 \, (\Sigma \, y)^2}}$$

R= Co-efficient of correlation

Correlation and regression of weather parameters with per cent disease index (PDI)

The epidemiology study was conducted in Rabi 2020–21 at Shivamogga's College of Agriculture. The powdery mildew susceptible cultivar Arka Anamika was chosen for the investigation. In order to score the incidence of powdery mildew disease, ten plants were chosen at random. Using the previously mentioned 0- 5 scale, observations were made on a weekly basis. Weekly meteorological characteristics, such as rainfall, maximum and minimum temperatures, relative humidity in the morning and evening, and wind speed, were found to be connected with the development of the disease. Throughout the crop season, weekly meteorological parameters were consistently observed, the average of these characteristics was determined, and a correlation matrix was developed. With the aforementioned parameters, additional multiple regression was performed in respect to PDI.

Estimation of potassium and sulphur content

Digestion of plant sample

After adding 10 milliliters of the di-acid mixture to a 100 milliliter conical flask containing 0.5 grams of plant material, the flask was heated to a higher temperature in the digestion chamber until red NO2 fumes were produced. Digestion was then carried out until the volume was reduced to approximately three to five milliliters. Snow-white residue or the liquid's loss of color indicated that the digestion was complete. After cooling, add distilled water to make up the volume, then filter the mixture using Whatman No. 1 filter paper. To find K and S, an aliquot of the solution was employed.

Determination of potassium in plant sample

Fed the digested plant sample solution into the flame photometer, recorded the reading and compared the unknown sample readings with the standard curve and calculated the amount of % K (Thaung., 2007).

$$\% \text{ K} = \frac{\text{Graph ppm} \times \text{Vol. of digested sample} \times \text{Vol. made up}}{10^6 \times \text{Wt. of sample} \times \text{Aliquot taken}} \times 100$$

Determination of sulphur in plant sample

Digested sample of 5 ml was taken in a 50 ml volumetric flask, and added 1 ml acid seed solution + 1 ml gum acacia + 0.5g $BaCl_2$, Volume was made up to 25 ml and the sample was fed to the spectrophotometer. Recorded the turbidity or % transmission at 420 nm within 20 min.

$$\% \text{ S} = \frac{\text{Graph ppm} \times \text{Vol. of digested sample} \times \text{Vol. made up}}{10^6 \times \text{Wt. of sample} \times \text{Aliquot taken}} \times 100$$

Correlation of K and S content by the foliar spray of potassium chloride and potassium sulphate on powdery mildew disease and yield

Correlation of potassium and sulphur content with the powdery mildew disease severity and yield in potassium chloride, potassium sulphate treated plots and untreated control was done.

RESULTS

Symptomatology

White, tiny, powdery patches on the upper surface of the young plant's lower leaves were the earliest indications of the illness. Subsequently, the powdery spots spread outward, covering the whole leaf surface and causing defoliation. White mycelial growth was eventually seen on the petiole and stem as well. The powdery mildew symptom development observations on the okra cultivar Arka Anamika were noted.

The upper surface of the leaves began to produce tiny, white, grayish dots eight days after the inoculation. Little white spots grew and combined to produce huge white dots fourteen days following the vaccination. Twenty days after the inoculation, around 50% of the leaf area was covered in powdery growth; twenty-five days later, mycelia covered more than 70% of the leaf area. The entire leaf surface was covered in a white, powdery material 32 days after the inoculation, and there was also visible leaf defoliation.

Morphology of the pathogen

The morphology of the fungus was examined in the laboratory by spreading a suspension of fungal spores on a clean glass slide and seeing it under a microscope at 10 X, 40 X and 100 X. Conidia were produced single or in short chains, were barrel or cylindrical in shape, hyaline, and non-septate. Conidia are produced in basipetal succession and measured 49.39 × 21.78 µm.

Table 1: Symptom development of powdery mildew on okra cultivar Arka Anamika under glasshouse condition

Incubation period (days)	Symptom development
8	Production of white greyish small spots on upper surface of the leaves
14	Enlargement of tiny white spot and coalesce to give large white spots
20	White powdery growth covering 50 per cent of leaf area
25	>70 per cent of leaf occupied white powdery growth
32	Entire leaf was covered with powdery growth, defoliation of leaves was seen

Different modes of inoculation

Fungal spores collected from bhendi leaves were inoculated to the healthy plants of susceptible bhendi cultivar Arka Anamika following different techniques as mentioned in “Material and Methods”.

Spraying of aqueous conidial suspension showed maximum per cent disease index of 61.6 per cent followed by dusting conidia using camel hair brush (56 %) and touching leaves of test plants with infected leaves full of conidia (42.1 %). Least per cent disease index was observed in case of shaking twigs of infected leaves over plants (17.19 %) and making injuries and inoculating (15.28 %). Thus, pathogenicity was proved by spraying aqueous conidial suspension.

Susceptible stage of the crop against powdery mildew infection caused by *E. cichoracearum*

The experiment was conducted on bhendi variety Arka Anamika to find out the most vulnerable stage of the crop against powdery mildew infection as explained in "Material and Methods".

The findings showed that the plants that were 60 days old had the highest percentage disease index (64.65%), followed by those that were 50 days old (40.15%) and 40 days old (27.14%). Plants that were 30 days old had the least amount of PDl (10.23%). The percentage disease index rose along with the crop's age, but at a certain point, the percentage disease index fell as the crop's age climbed.

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Table 2: Evaluation of different techniques on inoculation in relation to powdery mildew development on susceptible bhendi cultivars

SI No.	Modes of inoculation	Percent disease index (PDI)
1.	Spraying aqueous conidial suspension	61.6 (51.7)*
2.	Swabbing conidial suspension with cotton	34.45 (35.94)
3.	Making injuries and inoculating	15.28 (23.01)
4.	Shaking twigs of infected leaves over plants	17.19 (24.50)
5.	Dusting conidia using camel hairbrush	56.0 (48.44)
6.	Touching leaves of test plants with infected leaves full of conidia	42.1 (40.45)
S. Em± C.D at 1%		0.329 1.422

* Figures in the parentheses are arc sine transformed values

Table 3: Determination of susceptible stage of the crop against powdery mildew caused by *E. cichoracearum*

SI No.	Age of the crop (Days)	Percent disease index(PDI)
1.	15	0 (0)
2.	20	0 (0)
3.	30	10.23 (18.65)*

4.	40	27.14 (31.40)
5.	50	40.15 (39.32)
6.	60	64.65 (53.52)
7.	70	21.92 (27.91)
8.	80	10.74 (19.13)
S. Em ± C.D at 5 %		1.412 4.235

* Figures in the parentheses are arc sine transformed values.

Chlorophyll content in different disease scales (0-5) of healthy and powdery mildew infected leaves

Powdery mildew has an effect on bhendi's chlorophyll concentration. Chlorophyll concentration was calculated in accordance with the "Material and Methods" explanation, and the disease was rated on a scale of 0 to 5.

The findings showed that the highest total chlorophyll content of 0.327 mg/g was found in mildewed leaves on the 0-scale, followed by mildewed leaves on the 1-scale (0.303 mg/g), 2-scale (0.284 mg/g), and 5-scale (0.212 mg/g) leaves with the lowest total chlorophyll content.

The maximum total chlorophyll of 0.327 mg/g was observed across the various illness scoring scales, which is far better than the other disease scale. Mildewy leaves on the 1-scale came in second with 0.303 mg/g. There was the least amount of chlorophyll (0.212 mg/g) in 5-scale mildewed leaves.

Chlorophyll ‘a’

The findings showed a considerable difference in the amount of chlorophyll "a" in various mildewed leaf scales. Chlorophyll "a" reached its highest in mildewed leaves on the 0-scale (0.230 mg/g), which was much higher than that of the other disease scales. In mildewed leaves on the 1, 2, 3, and 4 scales, it was 0.225 mg/g, 0.209 mg/g, 0.206 mg/g, and 0.174 mg/g, respectively. On a 5-scale of mildewed leaves, the lowest chlorophyll "a" level was found (0.155 mg/g fresh weight).

Chlorophyll ‘b’

According to the results, there were considerable differences in the chlorophyll 'b' content among the various scales of mildewed leaves. The highest chlorophyll "b" content was found in mildewed leaves on the 0-scale (0.083 mg/g), followed by 0.081 mg/g, 0.075 mg/g, and 0.067 mg/g in mildewed leaves on the 1, 2, and 3 scales, respectively. The lowest amount of chlorophyll "b" (0.044 mg/g fresh weight) was found in mildewed leaves on a scale of 4 and 5.

Correlation and multiple linear regression analysis between severities of powdery mildew in relation to weather parameters

Using correlation, a relationship was established between environmental parameters such as maximum and minimum temperature, maximum and minimum relative humidity, rainfall and wind speed with the percent disease index in susceptible cultivar Arka Anamika.

According to Table 4, there was a negative correlation between powdery mildew (PDI) and weather parameters in 2020–21. Specifically, there was a negative correlation with minimum temperature (-0.43748), maximum temperature (-0.32417), and rainfall (-0.05103). However, there was a significant negative correlation with maximum relative humidity (-0.69285), minimum relative humidity (-0.71392), and wind speed (-0.61514).

The results of the multiple linear regression between the powdery mildew index (PDI) and weather parameters for the 2020–21 season are shown in Table 5. The regression coefficients for wind speed, rainfall, maximum and minimum temperatures, relative humidity, and PDI were found to be, respectively, -11.37, 1.51, -1.65, -0.98, -0.06, and -6.96. The highest relative humidity was discovered to be a significant factor in determining the severity of the disease ($P < 0.05$).

After fitting the multiple linear regression equation to the data, the following equation was found: Y= 575 - 11.37 X1+ 1.51 X2- 1.65 X3*- 0.98 X4- 0.06 X5- 6.96 X6. The values of X1 and X2 are the maximum and minimum temperatures, respectively, of X3, X4, X5, and X6 are the percentage of rainfall and mm and km/hr, RH, and RH, respectively.

The data indicated that for every unit change in maximum temperature, relative humidity, rainfall, wind speed, and percent illness index, the percentage disease index fell by 11.37, 1.65, 0.98, 0.06, and 6.96 times, respectively. The minimum temperature change caused the PDI to rise by 1.51 units, and an R2 value of 0.829 was noted, indicating that 83% of the fluctuation in the disease index percentage was caused by changes in meteorological conditions.

Prediction model by 'Simple regression' method on powdery mildew disease development

Using a 0–5 scale (Gawande and Patil, 2003), the powdery mildew disease severity was measured every seven days in 2020–21 and converted to a percent disease index (PDI). Furthermore, the basic regression equation method was used to forecast the progression of disease.

The range of anticipated values was 12.09 PDI to 69.29 PDI. The projected PDI values were in close proximity to the actual PDI values during the 49th, 2nd, and 3rd meteorological weeks. The discrepancy between the observed and expected PDI values peaked at the 5th meteorological week (-24.89). Therefore, a straightforward regression equation was suitable for the forecast, providing a prescient explanation of the powdery mildew.

Table 4: Effect of weather parameters on severity of bhendi powdery mildew caused by *E. cichoracearum* during 2020-2021.

Months	Meteorological Standard week	PDI	Temperature(◦C)		Relative humidity (%)		Rainfall (mm)	Wind speed Km/hr.
			Max.	Min.	Max.	Min.		
November 16-22(2020)	46	0	30.3	18.7	84	72	0	6.4
November 23-29	47	0	31.3	15.2	91	65	0	4.3
November 30-6	48	0	29.4	16.8	94	74	0	5.3
December 7-13	49	0	28.7	17.5	93	80	16.2	7.0
December 14-20	50	10.33	30.9	15.9	93	65	0	3.2
December 21-27	51	13.33	29.9	14.5	85	60	0	4.9
December 28-3	52	20	31.2	15.2	82	50	0	4.1
January 4-10 (2021)	1	27.22	29.7	18.3	86	64	59	5.0

January 11-17	2	38.88	30.1	17.7	80	64	0.8	5.3
January 18-24	3	47.77	31.8	16.1	74	46	0	3.4
January 25-31	4	52.2	31.8	14.1	82	34	0	2.7
February 1-7	5	65	31.6	15.1	77	37	0	4.0
February 8-14	6	44.4	31.5	13.5	87	29	0	3.7
February 15-21	7	34.4	30.9	14.7	84	34	0.6	4.0
February 22-28	8	21.66	31.8	18.4	78	46	27.6	4.4
March 1-7	9	10.55	34.1	19.7	83	35	0	5.4

Table 5. Multiple linear regression analysis for influence of weather parameters on bhendi powdery mildew disease

Constant	X_1	X_2	X_3	X_4	X_5	X_6
575	-11.37	1.51	-1.65	-0.98	-0.06	-6.96
					R^2	Multiple R
$Y= 575-11.37 X_1+1.51 X_2-1.65 X_3^{*}-0.98 X_4-0.06 X_5-6.96 X_6$					0.829679	0.910867

*- significant ($P < 0.05$)

Where,

X_1 –Max. Temperature
X_2 –Min. Temperature
X_3 –Max. RH
X_4 –Min. RH
X_5 –Rainfall
X_6 –Wind speed

Table 6. Chlorophyll content in different: disease scales (0-5) of healthy and powdery mildew infected leaves

SI No.	Disease scale	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total chlorophyll (mg/g)

1.	0	0.230	0.083	0.327
2.	1	0.225	0.081	0.303
3.	2	0.209	0.075	0.284
4.	3	0.206	0.067	0.270
5.	4	0.174	0.044	0.219
6.	5	0.155	0.044	0.212
S. Em± C.D at 1%		0.004 0.017	0.002 0.007	0.007 0.030

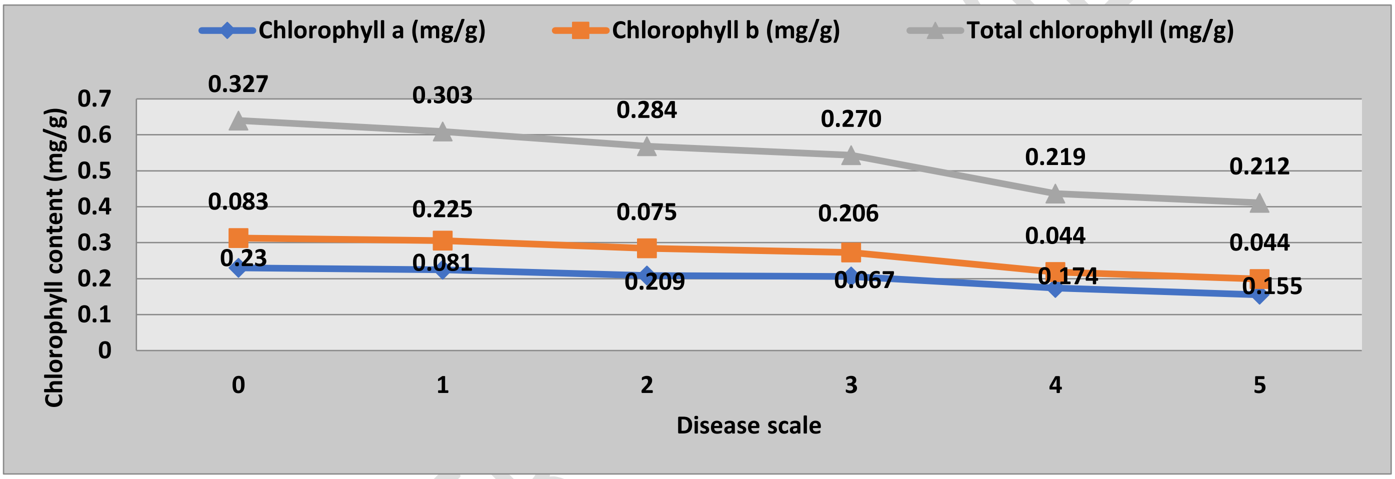

Figure 1. Chlorophyll content in different disease scales (0-5) of okra powdery mildew

<u>Correlation of K and S content by the foliar spray of Potassium chloride and Potassium sulphate on powdery mildew disease and yield</u>

In susceptible cultivar Arka Anamika, an investigation was conducted to determine the link between K content and S content with the percent disease index and yield under field conditions.

The link in field conditions between yield, K content, S content, and percent disease index. The findings demonstrated a significant association with yield (-0.9997) and a negative correlation with the percent illness index for yield, K content, and S content. The yield of the crop grew as the potassium and sulfur contents did, indicating a favorable link between the two.

Table 7: Correlation between K and S concentration of leaf tissue with PDI and yield of bhendi

	PDI (%)	Yield (q/ha)	K content (%)	S content (%)
PDI (%)	1			
Yield (q/ha)	-0.9997*	1		
K content (%)	-0.9947	0.9936	1	
S content (%)	-0.5259	0.5351	0.4357	1

* − Correlation is significant at 5 % level

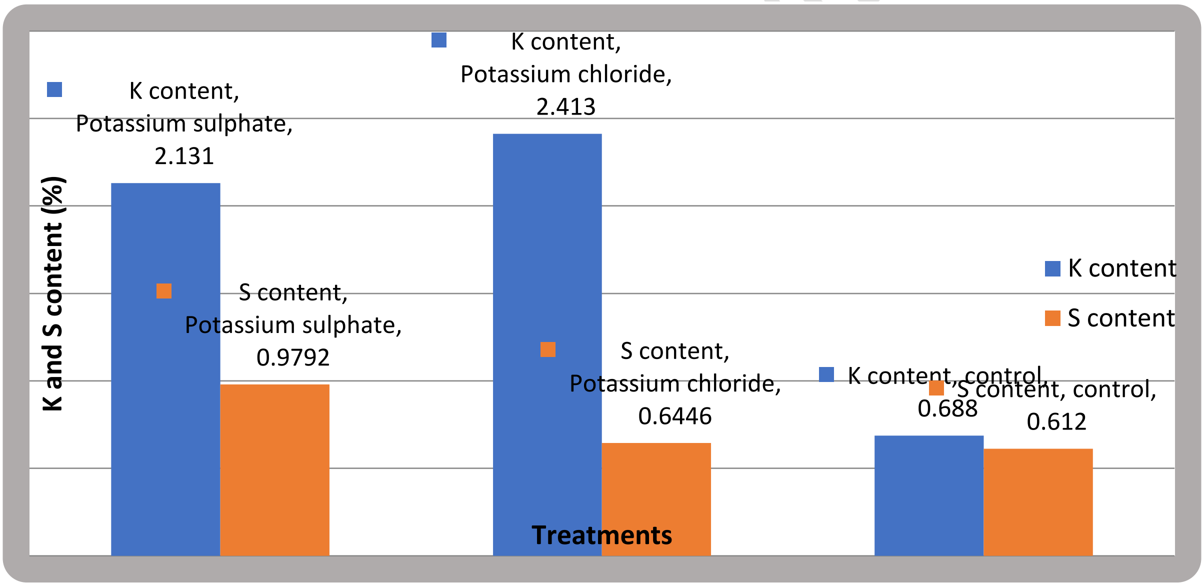

Figure 2: Effect of foliar application of KCl and K_2SO_4 on leaf tissue concentration of bhendi

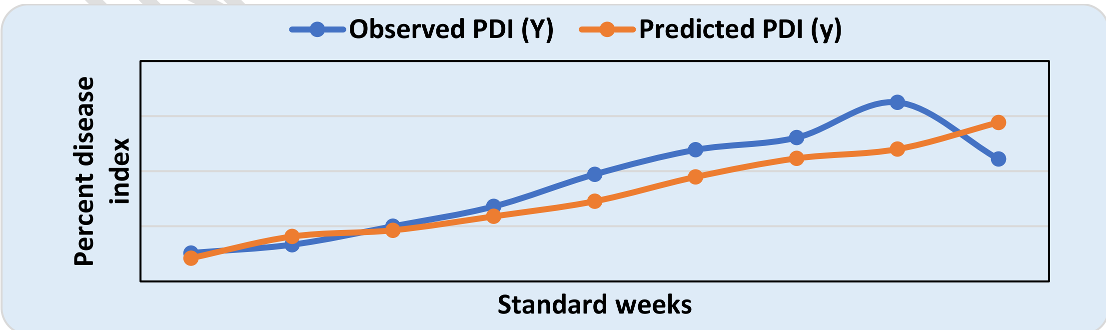

Figure 3- Observed and Predicted PDI values as per the simple regression equation for bhendi powdery mildew during 2020-21

DISCUSSION

Chlorophyll content in different disease scales (0-5) of healthy and powdery mildew infected leaves

Important organelles found in plant cells called chloroplasts aid in the manufacture of chlorophyll content, which is crucial for photosynthetic activity and ultimately boosts agricultural productivity. The study on the estimation of chlorophyll "a," "b," and total content in different disease grade leaves revealed that, as is well known, the destruction of chloroplasts is a common feature in foliar diseases. Thus, 5-scale mildewed leaves were highly susceptible to reaction with the lowest total chlorophyll content (0.212 mg/g), and 0-scale mildewed leaves showed immune response with the highest total chlorophyll content. (0.327 mg/g).

The findings align with Shivanna's (2004) findings, which linked the okra powdery mildew-induced drop in photosynthetic rate to a comparable decrease in healthy leaf area. Powdery mildew infection in woody plants reduces the size of the photosynthetic electron transport system, affecting both the acceptor and donor sides of photosystem II, according to the observation of the fluorescence transient (Percival and Fraser, 2002). The powdery mildew-infected leaves of rubber plants had significantly lower levels of chlorophyll contents, maximal photochemical efficiency (Fv/Fm), real photochemical efficiency of photosystem II (PSII), and electron transport rate (ETR). (Wang *et al.* 2014)

A foliar spray of potassium chloride and potassium sulphate was used to correlate the potassium and sulfur content with powdery mildew. The results showed that an increase in K and S content was correlated with a decrease in PDI and an increase in yield. This may be because of a change in the osmotic potential that prevents conidia from germination and sporulation.The findings support the theory that potassium chloride, by an osmotic influence on spore germination, lessens the symptoms of wheat powdery mildew. (Kettlewell *et al.*, 2000).

Potassium encourages epidermal cells to form thicker outer barriers, which fends against disease invasion. Additionally, K affects plant metabolism because low-K plants collect simple N molecules like amides, which are utilized by invasive plant diseases, and have poorer protein synthesis. The degree of an infestation is directly correlated with tissue stiffening and stomatal opening patterns. (Marschner, 1995).

Application of K decreases helminthosporium leaf blight severity and increase grain yields in wheat (Sharma and Duveiller, 2004). *Erysiphe graminis* intensity increases with decrease in K content (Menzies *et al*., 1992). Since Sulphur is having anti-fungal properties thus helped in the reduction of the disease. Ehret *et al*. (2002) reported that KCl, $MgSO_4$, and K_2HPO_4 significantly reduced mildew counts with multiple applications in case of tomato powdery mildew, because of the osmotic (concentration) and specific-ion effects.

Weather parameters

The powdery mildew pathogen spreads more quickly in warm weather conditions with low relative humidity. The potential of the powdery mildew's conidia to germinate at lower humidity levels may have a significant role in the plant's ability to spread in dry climates (Wang et al., 2014). According to Khun (2016), powdery mildew incidence declines with increasing rainfall. A temperature range of 19.7 to 28.9oC, a humidity range of 60.2 to 87.7%, and 5.1 hours of sunshine on average were determined to be optimal for the development of powdery mildew disease on sesamum. (Jadav., 2018).

Six regression coefficients—11.37, 1.51, -1.65, -0.98, -0.06, and -6.96—were found for the independent weather variables of maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, rainfall, and wind speed, respectively, after the data was subjected to multiple linear regression analysis. All of the weather parameters for 2020–21 may be found in the equation $Y= 575 – 11.37 X1 + 1.51 X2 – 1.65 X3^* – 0.98 X4 – 0.06 X5 – 6.96 X6$, which has an R2 value of 0.829, meaning that 83% of the variance in illness intensity can be attributed to the weather factors. The highest relative humidity was discovered to be a significant factor in determining the severity of the disease ($P < 0.05$). A regression model created to forecast PDI revealed that various meteorological factors had varying effects and were accountable for either an increase or decrease in PDI. The results were obtained were in agreement with the results of Thaung (2007); Goswami (2016); Bharath (2023).

CONCLUSION

When several artificial inoculation strategies were examined to demonstrate the pathogenicity, spraying conidial suspension was shown to be the most effective approach, with a PDI of 61.6, while the pin prick method had the lowest PDI (15.28%). The pathogen's ectophytic nature explains this. The crop is sensitive to powdery mildew at stage 60 DAS, with a maximum PDI of 64.65%. This is because nutrients are translocated from the source to the sink in later stages of the plant's life, rendering it susceptible. When the amount of chlorophyll in various disease-grade leaves is estimated, it is found that leaves with mildewed 0-scale content have larger amounts of chlorophyll "a," chlorophyll "b," and total chlorophyll, at 0.230, 0.083, and 0.327 mg/g, respectively, while leaves with mildewed 5-scale content have the lowest amounts.

The data is fitted with the multiple linear regression equation, which has the following values: Y= 575 - 11.37 X1+ 1.51 X2- 1.65 X3*- 0.98 X4- 0.06 X5- 6.96 X6.The variables with an R2 value of 0.829 are X1 - Maximum Temperature (ʦ C), X2 - Min. Temperature (Ŧ C), X3 - Maximum RH (%), X4 - Min. RH (%), X5 - Rainfall (mm), and X6 - Wind speed (km/hr). Powdery mildew was predicted a week ahead of schedule. With R = 0.885 and R2 = 0.784, the basic regression equation was Y = 12.09 + 0.76 x. The range of anticipated values was 12.09 PDI to 69.29 PDI. During meteorological weeks 49, 2, and 3, the projected and observed PDI values were nearly equal. Between the 52nd and 1st week, the maximum apparent rate of infection (r) of 0.0758 was recorded; this value was comparable to the "r" value between the 3rd and 4th week. The maximum AUDPC value (410.2) was acquired on February 7, 2021 (5th MW), while the lowest (82.81) was obtained one week after the initial infection on December 27, 2020. The disease progressed steadily from the day of infection. (51st MW)..

A foliar spray of potassium chloride and potassium sulphate was used to correlate the potassium and sulfur content with powdery mildew. The results showed that an increase in K and S content was correlated with a decrease in PDI and an increase in yield. Of the five chemical salts tested, potassium sulfate (97.26%) and potassium chloride (97.07%) showed the highest percentage of germination inhibition at 0.3 percent concentration.

Future scope

• Research on analysis of fungicidal residues.

• Plant biochemical analysis on the impact of protein, amino acid, and phenol content on the prevention or treatment of disease.

• Molecular analysis of various isolates of the disease known as Bhendi powdery mildew, originating from various geographical areas.

• It is necessary to research the fol- iar use of potassium salts, such as KCl, K2SO4, and MgSO4, prior to disease infection.

- It is necessary to investigate the correlation between the concentrations of K and S in leaf tissue across all treatments at all growth stages

Ethical approval. This article follows experimental guidelines and this research

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