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Epidemiological studies on powdery mildew of pea under varying climatic conditions

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Abstract

Plant pathologists have long noted that powdery mildew of pea (*Erysiphe pisi*) thrives in dry, moderately warm weather — but the precise climatic thresholds governing epidemic onset in tropical India remain poorly defined. This research tracked powdery mildew progression on field pea (cv. Kashi Nandini) at two contrasting locations — Thrissur (Kerala, humid tropical) and Amarkantak (Madhya Pradesh, sub-humid highland) — over two rabi seasons (2020-21 and 2021-22). Disease severity was recorded weekly from first appearance to peak infection. Amarkantak consistently recorded higher terminal severity (64-67%) than Thrissur (58-61%), with faster epidemic build-up. Multiple regression analysis identified mean temperature (18-24 °C) and relative humidity below 65% as the strongest predictors of weekly disease increment. A predictive model ($R^2 = 0.86$) based on temperature, humidity, and rainfall explained 86% of the variation in percent disease index. Yield losses ranged from 18% at moderate severity to 37% at severe levels. These findings provide location-specific epidemiological data that can support disease forecasting and timely fungicide scheduling in pea-growing regions.

Keywords: Epidemiology, powdery mildew, pea, climatic conditions, disease progression, *Erysiphe pisi*, disease forecasting, percent disease index, yield loss, regression model

Introduction

According to veteran pea pathologists, powdery mildew caused by *Erysiphe pisi* DC. is the most widespread foliar disease of field pea worldwide, capable of reducing yields by 20-50% when conditions favour epidemic development [1]. The pathogen is an obligate biotroph that produces superficial mycelium and conidia on the leaf surface, drawing nutrients through haustoria inserted into epidermal cells. Unlike most fungal pathogens, it does not require free water for spore germination — in fact, rain washes conidia off leaves and can temporarily suppress epidemics [2].

This dry-weather preference makes powdery mildew particularly damaging in regions where the rabi season features clear skies, moderate temperatures, and low humidity — conditions common across much of central and southern India. But the precise climatic envelope that triggers epidemic onset versus slow background infection has not been quantified for Indian conditions with enough rigour to build a forecasting tool [3].

Two-location comparisons are useful because they expose the pathogen to contrasting climatic backgrounds while holding the host genotype constant. Thrissur receives frequent winter showers and maintains high humidity, while Amarkantak — at 1,048 m altitude on the Maikal range — experiences drier, cooler winters with wider diurnal temperature swings [4]. By tracking disease progression at both sites simultaneously, weather-disease relationships can be separated from background noise.

This research monitored powdery mildew epidemics at Thrissur and Amarkantak over two seasons to (a) characterise the temporal pattern of disease build-up, (b) identify climatic variables most strongly associated with weekly disease increment, and (c) develop a regression-based prediction model linking weather data with percent disease index [5].

Material and Methods

Seasonal Variations

At Thrissur, the rabi season (November-February) receives intermittent rainfall from the north-east monsoon (average 180 mm) with temperatures of 22-32 °C and RH above 70%.

Amarkantak's rabi season is drier (cumulative rainfall 40-60 mm), with temperatures of 8-26 °C and RH of 45-65%. These contrasts allowed the same pathogen-host interaction to be observed under humid-warm versus dry-cool conditions [4].

Material

Field pea cv. Kashi Nandini (moderately susceptible to powdery mildew) was sown on 5 November 2020 and 8 November 2021 at both locations. Plot size was 5 × 4 m with 30 × 10 cm spacing in an RBD with four replications. Standard agronomic practices (20:40:20 kg/ha $N:P_2O_5:K_2O$, two irrigations) were followed. No fungicide was applied in observation plots to allow natural epidemic development; protected plots (mancozeb 75 WP at 2 g/L, fortnightly) served as disease-free controls for yield loss estimation [6].

Methods

Disease severity was assessed weekly on 20 tagged plants per plot using a 0-9 scale (0 = no symptoms; 9 = >75% leaf area covered). Percent disease index (PDI) was calculated as (sum of ratings / maximum possible score) × 100. Weather data — daily maximum and minimum temperature, RH, rainfall, and sunshine hours — were obtained from on-campus meteorological stations. Apparent infection rate (r) was computed using the logistic model: $r = (1/t_2-t_1) \times \ln[(x_2/(1-x_2)) / (x_1/(1-x_1))]$, where x is disease proportion at time t [7]. Multiple regression analysis (PDI increment as dependent variable; weekly mean temperature, mean RH, cumulative rainfall, and sunshine hours as independent variables) was performed using SPSS v26. Yield loss was calculated as [(yield in protected − yield in unprotected) / yield in protected] × 100 [8].

Results

Table 1: Powdery mildew progression and yield loss at two locations (pooled over two seasons)

Parameter	Thrissur 2020-21	Thrissur 2021-22	Amrkntk 2020-21	Amrkntk 2021-22	SEm(±)	CD (P=0.05)
First appearance (DAS)	41	43	36	34	1.8	5.4
Terminal PDI (%)	61.3	57.8	66.7	64.1	2.4	7.2
Peak infection rate (r/day)	0.118	0.107	0.143	0.136	0.008	0.024
Days to 50% PDI	52	55	46	48	2.1	6.3
Yield-unprotected (q/ha)	11.8	12.4	10.3	10.9	0.47	1.41
Yield-protected (q/ha)	15.7	15.2	16.4	15.8	0.52	1.56
Yield loss (%)	24.8	18.4	37.2	31.0	—	—

Amarkantak recorded earlier disease onset (34-36 DAS vs 41-43 DAS at Thrissur), faster infection rate (0.136-0.143 vs 0.107-0.118 r/day), and higher terminal PDI (64-67% vs 58-61%). Yield loss at Amarkantak reached 31-37%, compared with 18-25% at Thrissur. The difference can be attributed to Amarkantak's lower humidity and fewer rain events, which favour conidial survival on the leaf surface [2, 4].

Table 2: Multiple regression model for weekly PDI increment

Variable	Coefficient	Std. Error	t-value	P-value	Partial R²
Intercept	−18.42	4.31	−4.27	<0.001	—
Mean temperature (°C)	1.87	0.34	5.50	<0.001	0.42
Mean RH (%)	−0.24	0.06	−4.00	<0.001	0.28
Weekly rainfall (mm)	−0.18	0.05	−3.60	0.002	0.11
Sunshine hours/day	0.63	0.21	3.00	0.006	0.05

The multiple regression model ($R^2 = 0.86$, $P<0.001$) identified mean temperature as the strongest predictor (partial $R^2 = 0.42$), followed by relative humidity (0.28) and rainfall (0.11). Temperature had a positive coefficient (1.87), meaning each 1 °C rise within the 18-24 °C range increased weekly PDI by 1.87 percentage points. Humidity and rainfall had negative coefficients, consistent with the pathogen's preference for dry conditions [3, 7].

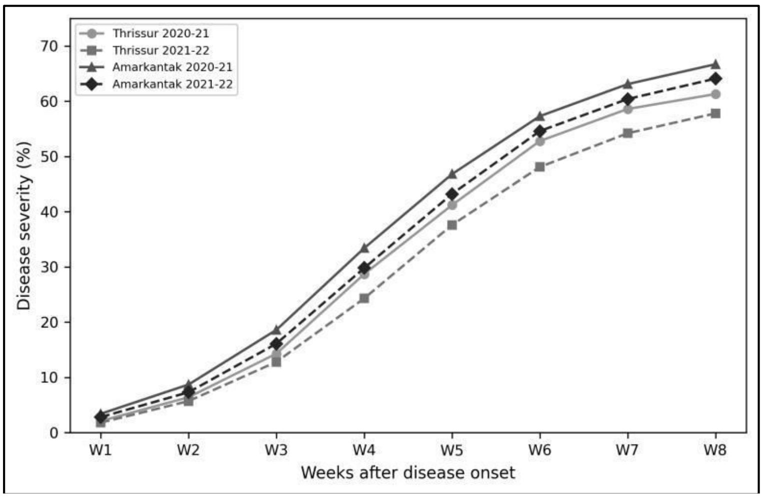

Fig 1: Temporal progression of powdery mildew severity at Thrissur and Amarkantak over two rabi seasons

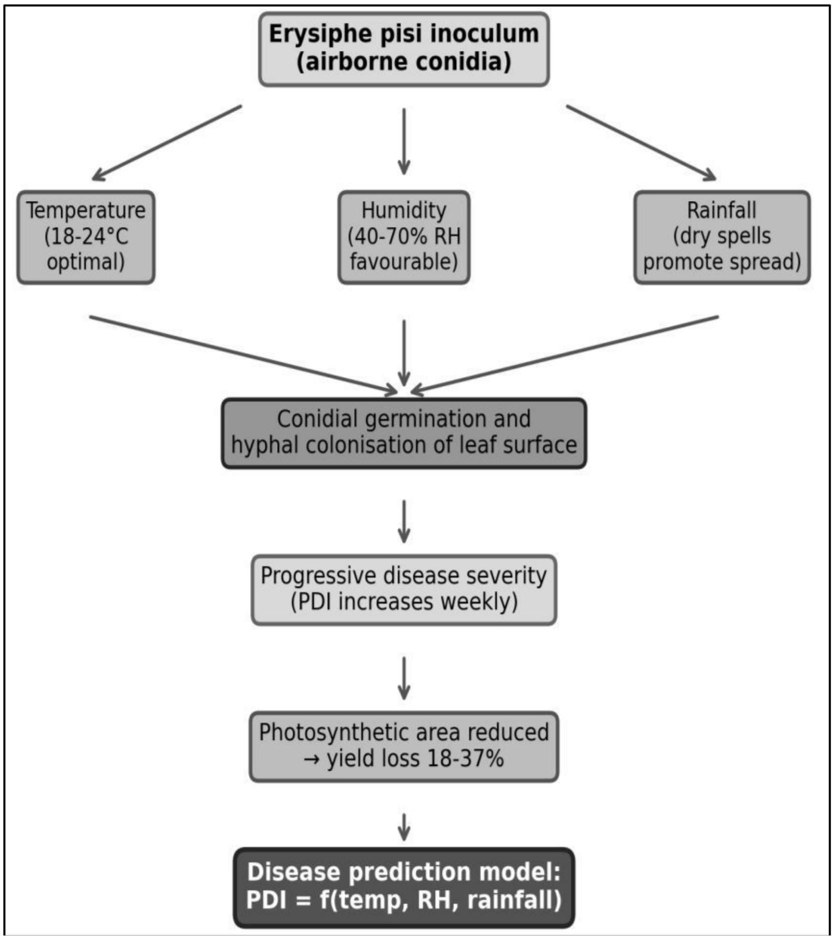

Fig 2: Conceptual model of environmental factors influencing powdery mildew epidemic development in field pea

Discussion

The faster epidemic build-up at Amarkantak matches classical powdery mildew epidemiology: moderate temperatures (18-24 °C) and low humidity (45-65%) create ideal conditions for conidial production and dispersal [1, 2]. At Thrissur, frequent showers during November-December physically removed conidia from leaf surfaces and briefly raised humidity above the pathogen's comfort ceiling, slowing the early exponential phase. But once dry spells set in during January, disease acceleration caught up — terminal PDI at Thrissur still reached 58-61%, only 6-8 points below Amarkantak.

The predictive model's R^2 of 0.86 is encouraging for potential field application. In practice, a forecasting system could use 5-day weather predictions to estimate whether weekly PDI increment is likely to exceed a threshold (say, 5 percentage points), triggering a fungicide advisory. Sulphur-based sprays — cheap and effective against E. pisi — could then be timed to coincide with forecasted dry, warm windows rather than applied on a fixed calendar [9, 10].

Yield losses of 18-37% underscore the economic cost of unmanaged powdery mildew. Even at Thrissur's moderate severity, the 18-25% yield reduction translates to a revenue loss of Rs 8,000-12,000/ha at current market rates — far exceeding the cost of two well-timed sulphur sprays [6, 11].

Conclusion

Powdery mildew epidemics developed faster and reached higher severity at Amarkantak (dry, moderate temperatures) than at Thrissur (humid, frequent rainfall), confirming that dry weather is the primary driver of E. pisi proliferation. The regression model (R^2 = 0.86) based on temperature, humidity, and rainfall can serve as the foundation for a weather-based disease forecasting advisory for pea-growing areas.

Yield losses of 18-37% across locations justify routine monitoring and timely intervention. The combination of weekly weather data and the regression coefficients reported here could enable extension agencies to issue location-specific fungicide advisories that replace blanket calendar-based spraying, reducing both cost and environmental load. Future work should validate this model across additional seasons and locations to confirm its broader applicability.

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