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DETERMINATION OF RELATIONSHIP OF ENVIRONMENTAL FACTORS WITH STRIPE RUST IN WHEAT

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ABSTRACT

Changes in climate scenario affect natural conditions in farming system, hence affect plant pests and diseases development. Universally, adverse effects of climate changes namely failing the ecosystem apparatuses that control the balance of plant pests and diseases, failing the plant resistance and the development of environmental situation supportive plant pests and diseases growth in general. The disposed cultivars and favorable ecological circumstances play part towards rust diseases in epidemic form. In this study meteorological data and disease incidence data were correlated to establish relationship between environmental variables and stripe rust development. Linear correlation was established among minimum and maximum air temperature and development of rust was positive. Impact of relative humidity could not be assessed because variation in range between minimum and maximum mean relative humidity remained non-significant during the period under study. However, data generated seems insufficient to conclude authentic result to determine the role of relative humidity in stripe rust development. Three genotypes having different responses against stripe rust were studied to correlate the response of yellow rust with epidemiological factors (temperature, relative moisture, and precipitation). Impact of meteorological factors indicated that environment significantly affected disease incidence and severity of yellow rust through its impact on development rate of the pathogen. Same cultivars responded differentially under unlike meteorological conditions.

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INTRODUCTION

Wheat in Pakistan is the main food grain, and a staple food in the nourishments. Wheat production in the country is well below than potential owing to reduced yields. Various biotic as well as abiotic factors are the reason for said situation. Among these, stripe rust occupies vital status (Wellings, 2011). Sustainable supply of good quality staple food i.e. wheat to increasing population of Pakistan, calls for accordingly enhanced in wheat yields as well. Sustainable wheat production is essential in order to accomplish the demand of wheat of the country in future and is impossible without rust management. The scientists are struggling enduringly to crack the yield obstacles.

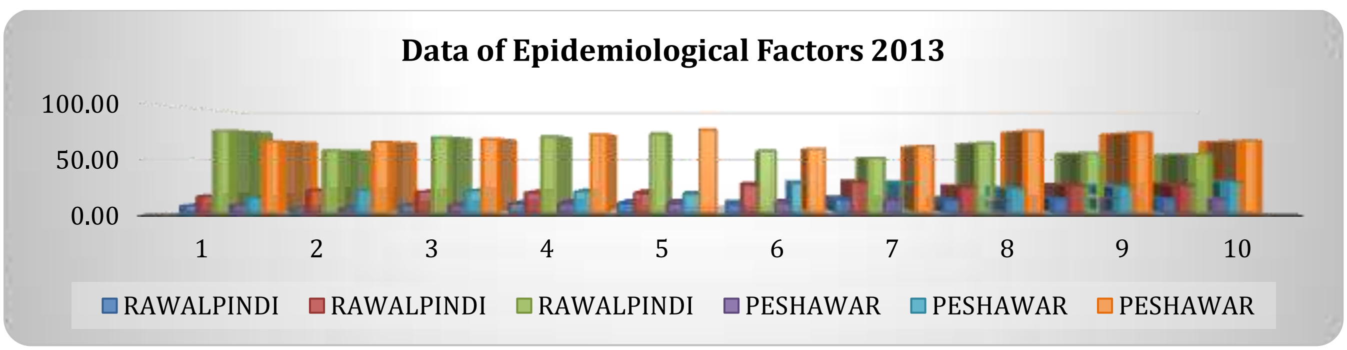
Climate is the effect of the interaction between different weather elements including temperature and atmospheric humidity. A critical study of the climate may often offer the possibility of the control or reduction of a plant disease by manipulation of the microclimate. Further, accurate data on the environmental variables is basic to the understanding of the development of plant diseases, and the economic control of plant diseases is based on these facts and figures. This knowledge will also help in forecasting the intensity of plant disease incidence, which again helps towards economizing on control measures. Change in climatic variables such as heat, fluctuations in day length, light concentration, plays a vital role in increased incidence of a disease because of the invasion of an innovative pathogen or its novel race/pathotype, the variation in host, prevailing pathogen, and the achievement of increased aptness in pathogen are factors contributing to fluctuation in disease intensity as well as severity. Same has been perceived in case of stripe rust of wheat. Generally, temperate areas with cool and moist spring and summer have been the conducive situation for epidemics of yellow rust. The novel races of *Puccinia striiformis* f.sp. *tritici* (PST) have considerably increased adaptation to warmer temperatures and consequently endure to cause disease epidemics (Afzal et al., 2018; Milus et al., 2009). The damaging epidemics have happened in Middle East, Central Asia, Western Asia, China, Northern and Eastern Africa in the recent past (Solh et al., 2012). Currently, stripe rust is disseminating steadily in a zone extending from Western Asia to Central Asia and the prospective damage might be severe (Hovmøller et al., 2010; Singh et al., 2004). Current research was aimed in the context designated above. Overall work has been conducted keeping in view an idea for the determination of relationship of environmental factors with coefficient of infection.

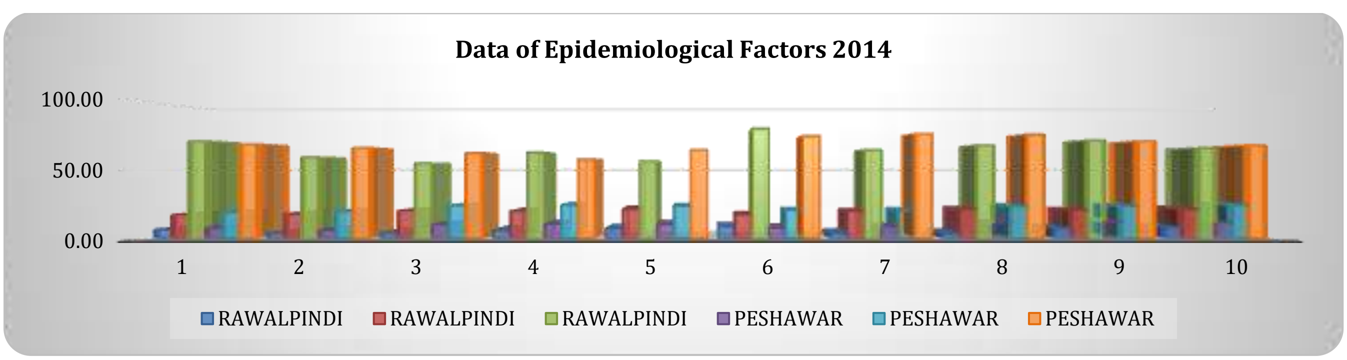
MATERIAL AND METHODS

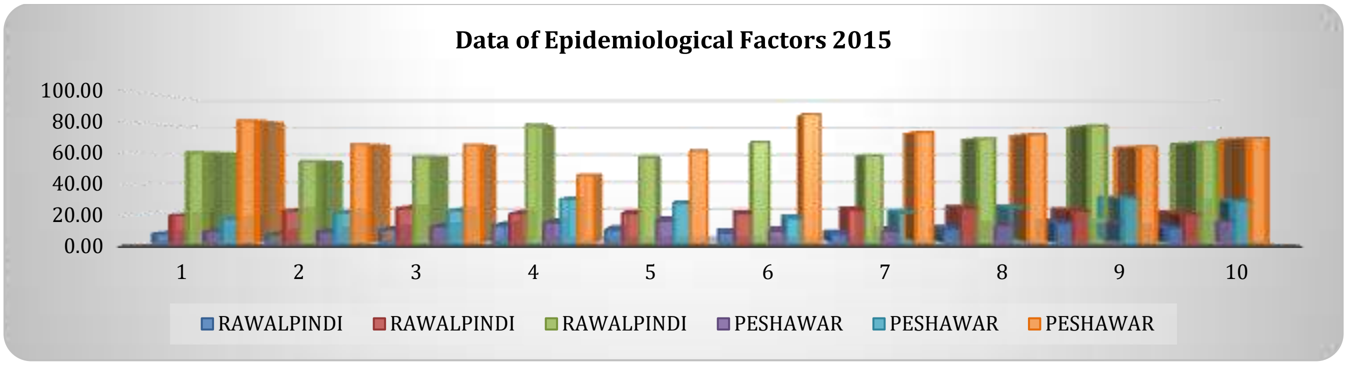
Trial was conducted in two sites i.e. Rawalpindi (33.6058ºN; 73.0437ºE) and Peshawar (34.0206° N, 71.4814° E) for three consecutive years (2013-2015) following agronomic recommendations (date of sowing, application of fertilizers). Three cultivars (INQILAB 91, SHAFAQ 2006, and MOROCCO) were investigated. The parentage and pedigree of genotypes tested have been presented in Table 1. These genotypes possessed fluctuating level of resistance to stripe rust epidemics. Data were noted in the month of April when the wheat variety Morocco developed maximum disease severity.

Achievement of weather-related Data

The meteorological data during February and March of each day for the years 2013-2015 of two locations (presented in Figure 1) were obtained from the corresponding weather stations, near to the areas where trials were conducted. Three climate factors lowest temperature, highest temperature, and average relative humidity (%) were addressed to characterize weather variables data of mean minimum temperature, mean maximum temperature, reckoned from minimum and maximum temperatures and average relative humidity (%) of the cropping seasons were used for the study.







1- 1st Feb to 6th Feb 2- 7th Feb to 12th Feb 3- 13th Feb to 18th Feb
4- 19th Feb to 24th 5- 25th Feb to 28th Feb 6- 1st March to 6th March
7- 7th March to 12th March 8- 13th March to 18th March
9- 19th March to 24th March 10- 25st March to 31stMarch
Figure 1: Data of epidemiological factors (2013; 2014 and 2015).

Table 1: Parentage/pedigree of wheat genotypes used to address epidemiology of stripe rust in current scenario.

Sr. No.	Genotype	Parentage/ Pedigree
1	INQILAB91	WL 711/CROW "S" PB1954-9A-0A-0A-0PAK
2	SHAFAQ -2006	LU 26/HD 21790/ 2*INQALAB 91 PB 28633P-2A-6A-0A
3	MOROCCO	Susceptible check cultivar

Statistical analysis

Correlation analyses were used to determine the association of each weather condition with severity of stripe rust (Khan et al., 1998). SPSS (IBM SPSS Version 20 for Windows, 2011) was used to conduct correlation analysis. The formula of linear regression line is $Y = a + bX$, where X is the instructive variable and Y is the dependent variable. The slope of the line is b, and a is the intercept (the value of y when $x = 0$). Modeling the association using practical data concerning two variables by fitting a linear equation is termed linear regression in Statistics. One variable is deliberated to be descriptive variable, and the other is dependent variable. For instance, a modeler is interested in relation of the weights of personalities to their tallness. A relationship between the variables of interest in the past attempting to fit a linear model to observed data will serve as a tool to decide to step forward. This does not indicate that one variable essentially reasons the other but that there is some noteworthy relationship among the two variables. A scatterplot can be a supportive instrument in defining the asset of the association between two variables. If there seems to be no relationship concerning the anticipated explanatory and dependent variables then fitting a linear regression model to the data probably will not generate a valuable model.

An appreciated arithmetical measure of association between two variables is the correlation coefficient, which is a value between -1 and 1 indicating the strength of the association of the data for the two variables.

RESULTS

Analysis of meteorological data

In Rawalpindi, the minimum temperature ranged from 2.4-8.1°C, Maximum temperature ranged 8-23.8°C and mean relative humidity 29-75.3%. The parameters (relative humidity, and temperature) at Peshawar fluctuated from 57.08-76.95(%) and 16.85-20.44(°C).

Analysis of disease data

Regression of the disease data of individual variety was conducted collectively. Among both locations, disease was more severe in Rawalpindi (Figures 2, 3). Different genotypes responded differentially in same location and cropping season (Figures 4, 5, 6). Disease was observed most severely during 2014 in three years (Figures 7, 8, 9). This is natural phenomenon controlled genetically.

The minimum temperature in the range given had stronger positive correlation in the locations and three varieties as well as three cropping seasons as compared to maximum temperature (Figure 10).

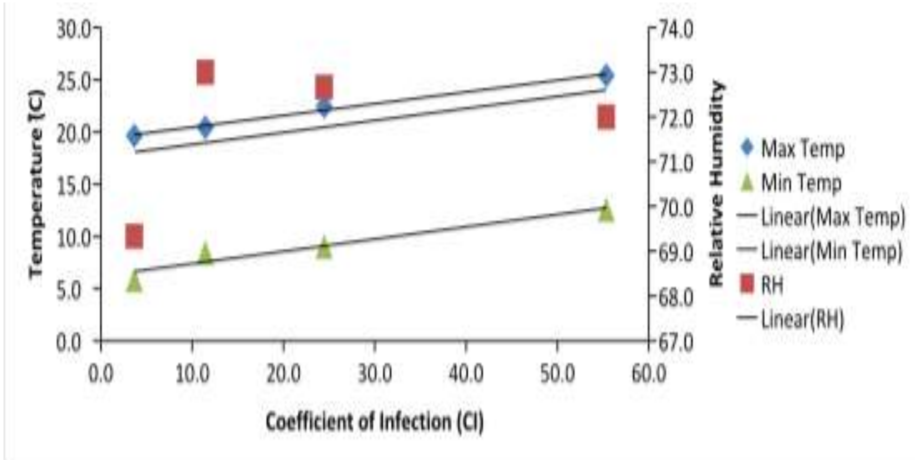


Figure 2: Relationship of weather factors and stripe rust in Peshawar (three years and three varieties).

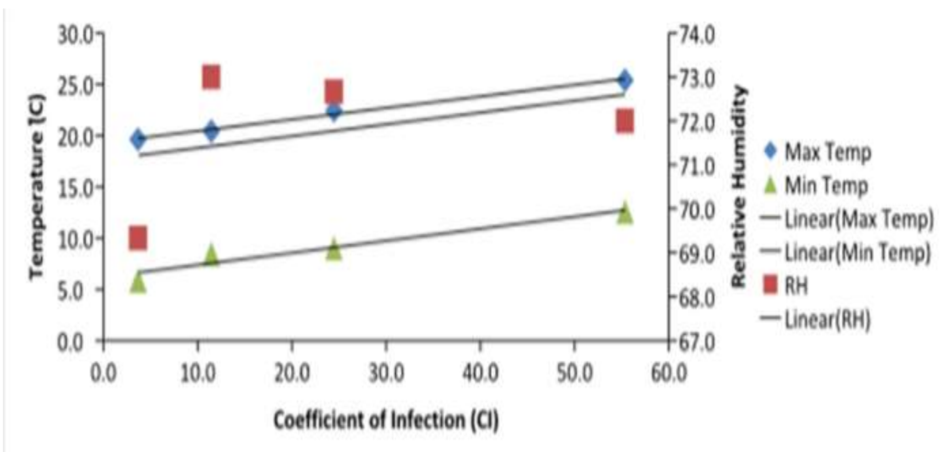


Figure 3: Relationship of weather factors and stripe rust in Rawalpindi (three years and three varieties).

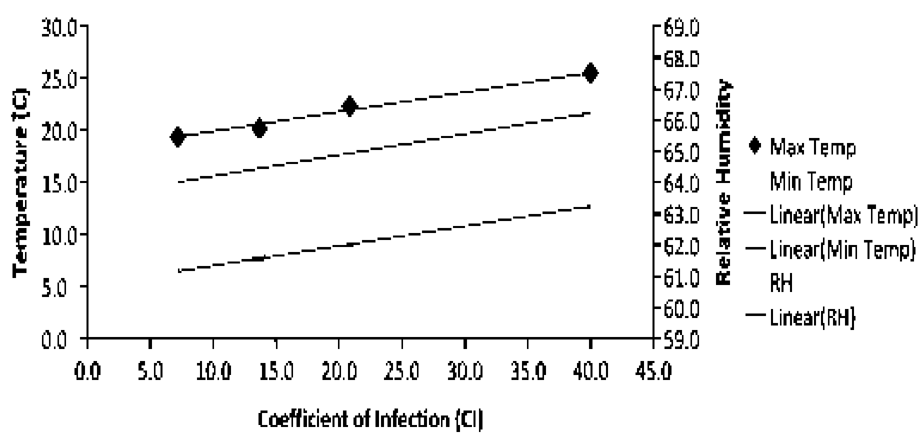


Figure 4: Relationship of weather factors and stripe rust in Inqilab-91 (three years and two locations).

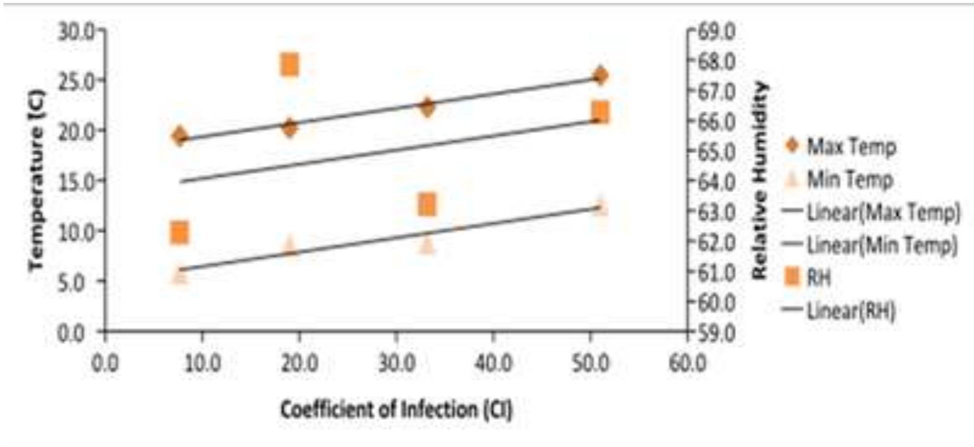


Figure 5: Relationship of weather factors and stripe rust in Shafaq-2006 (three years and two locations).

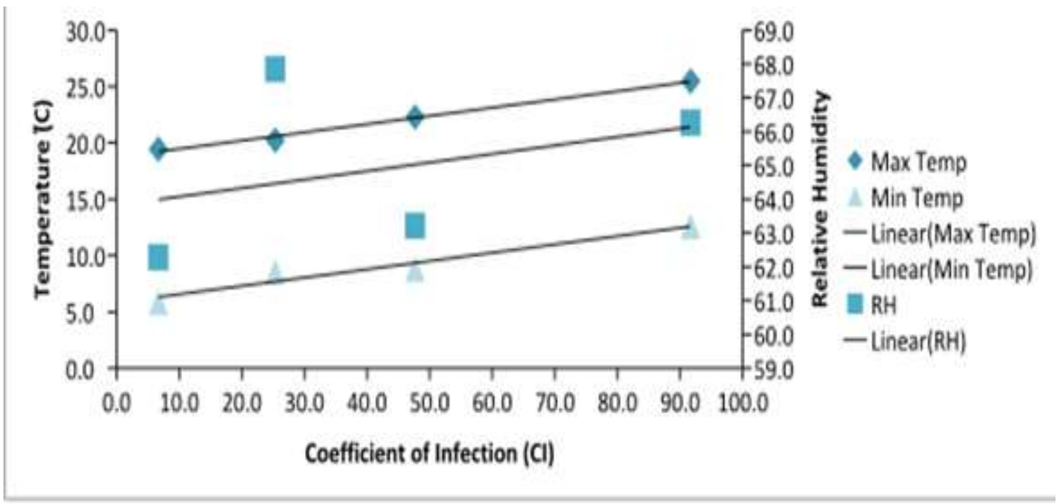


Figure 6: Relationship of weather factors and stripe rust in Morocco (three years and two locations).

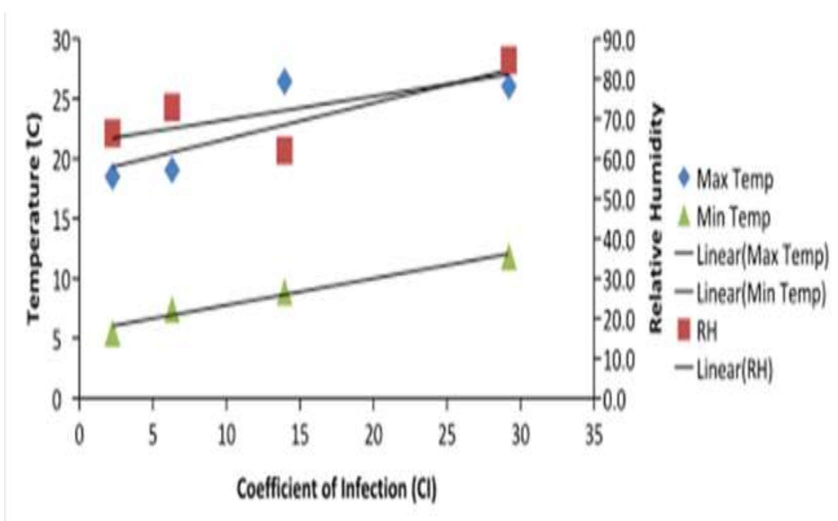


Figure 7: Relationship of weather factors and stripe rust 2013 (two locations and three varieties).

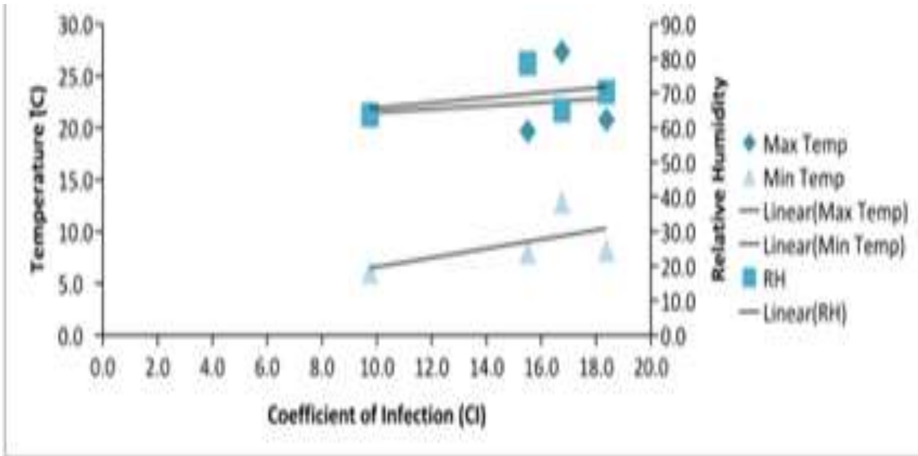


Figure 8: Relationship of weather factors and stripe rust (two locations and three varieties).

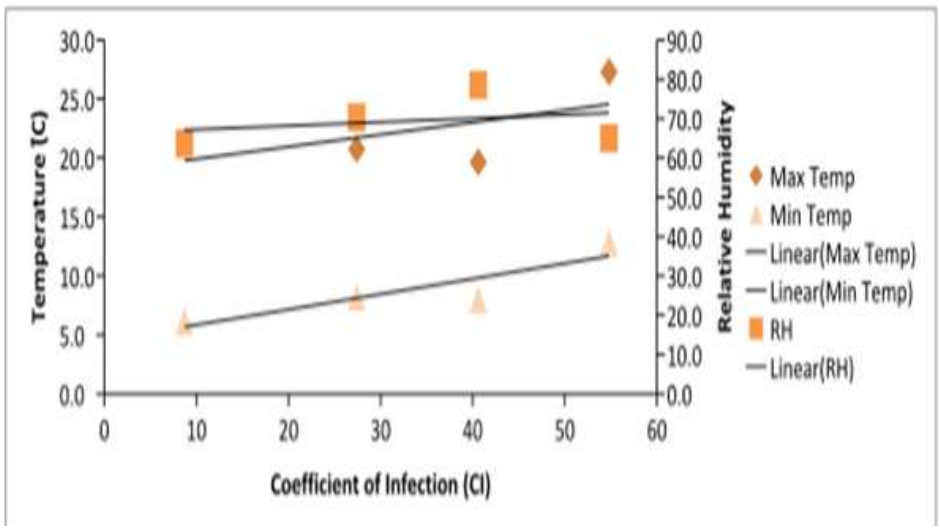


Figure 9: Relationship of weather factors and stripe rust 2015 (two locations and three varieties).

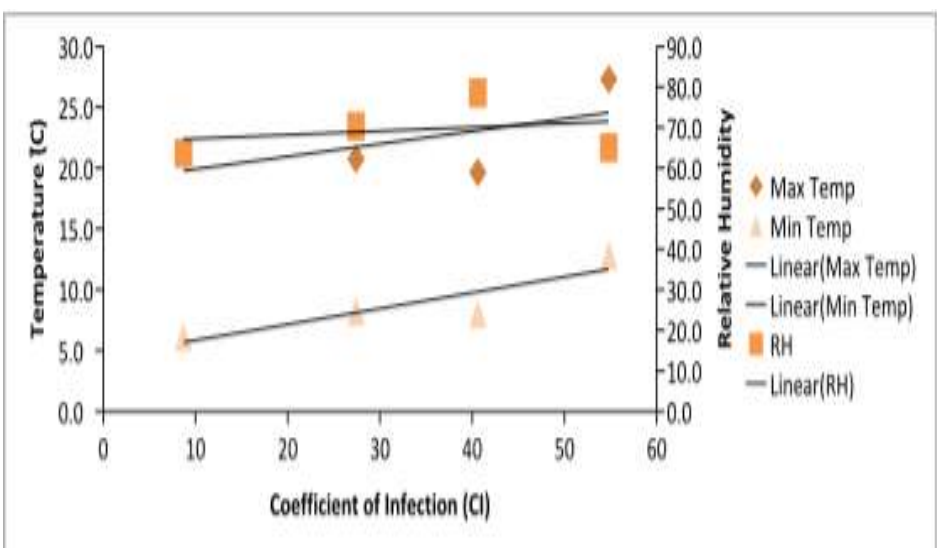


Figure 10: Overall relationship of weather factors and stripe rust.

DISCUSSION

Both the minimum and the maximum temperature affected disease development respectively (Murray et al., 2005). Results are supporting findings of Ali et al., 2017 that temperature minimum as well as maximum plays vital role in the development of stripe rust (Ali et al., 2017). Statistical analysis did not determine the role of relative humidity. It is attributed to the fact that relative humidity is crucial factor in the germination of spores but it is no more important afterward.

These results are in line with those of Stubbs (1985) who was of the opinion that night temperature is more important in stripe rust development than day temperature. A change in temperature influences the spread of infectious disease and survival between seasons directly. Due to changes in temperature and precipitation regimes, climate change may alter the host growth stage, development rate and pathogenicity of infectious agents, and the physiology and resistance of the host plant (Chakraborty and Datta, 2003). An alteration in temperature may support the growth of dormant pathogens leading to initiation of epidemic state. Increase in temperatures with sufficient soil moisture may raise evapotranspiration, building wet microclimate and may lead to incidence of diseases in the crop favored under these conditions (Mina and Sinha, 2008). Temperature is the environmental variable correlated with biological responses most usually and impact of it is measured almost across the world in studies on plant disease epidemics (Sutton et al., 1984). Application of mean and utmost everyday temperatures to decide if stripe rust happens in a location or if weather is deceptive. For instance, if a region has a diurnal temperature 22°C (minimum) and 28°C (maximum) while another region has a daily temperature range from 16°C and 34°C, then have a mean temperature everyday 25°C in both the locations. Conclusion based on average and utmost temperatures, the first location was more favorable to stripe rust. As a matter of fact, the subsequent location was more conducive for stripe rust since it had a period of time with temperatures that permitted disease development, whereas the minimum temperature in the first zone would be aggressive for disease to occur.

A peer review of data revealed that relative humidity during fifty-six days did not vary significantly and remained in the range (55 to 70) an ideal situation for disease development. Due to the fact, impact of humidity could not be detected. However, it is recommended that data used in this study seemed not enough to conclude a reliable finding. Therefore, it seems more appropriate to design experiments with sufficient treatment with respect to wide range of relative humidity (location wise as well as cropping seasons) to reach a concrete result. Moreover, it was revealed that susceptible cultivars generated desired information therefore, it is reasonable to select susceptible cultivars to conduct trial of optimization of weather factors.

Yellow rust can be anticipated by observing rainfall in a constituency and formation of drops of water (dew). More humidity endorses rust by supporting spore incubation, beside as well disturbs perseverance of spore negatively. Since spores sprout instantaneously provided moisture is present. Under favorable conditions, disease propagates rapidly once spores have germinated however reverse if factors responsible for disease development are not favorable. Environment is an important component of disease triangle. Host and pathogen interaction lead to infection only when ecological conditions are conducive despite the pathogen is virulent and host is vulnerable (Singh and Tewari, 2001; Stevenson, 1960). Thus, there is conscious struggle to make environment as part of central perception of disease triangle along vulnerable host and infectious pathogen, it was also understood that disease does not take place if all these factors do not act simultaneously (Raja et al., 2018).

CONCLUSION

The appropriate methods and techniques should be adopted to diminish grave damage of crop produce for sustainable productivity of crop. Cultivation of cultivars possessing inherited disease resistance and usage of fungicides are the disease management strategies. However, data of environmental conditions under which the disease flourishes the most, is fundamental need in both cases. Prediction of disease severity is crucial to sketch chemotherapy. Acquaintance of association of ecological circumstances to severity of disease has its significance assist in predicting epidemics of disease, so as to take measures preventive timely to curtail losses caused by disease. This information serves as fundamental tool in breeding for disease resistance also. There has been a noteworthy systematic achievement of the research work conducted on the subject how change in climate is perspective to influence plant diseases. Climate affects the incidence, frequency and severity of plant diseases. Likely environmental and meteorological alterations thus affect interaction between crops and pathogens. In the present study, weather-related data and disease incidence data were interrelated to launch equation between environmental variables and stripe rust development. Work conducted revealed a positive linear correlation between minimum and maximum air temperature and rust intensity. However, data generated seems inadequate to discover the role of relative humidity in stripe rust progress. Effect of relative moisture could not be evaluated for the reason that alteration in range between minimum and maximum mean relative moisture during the period under investigation persisted non-significant. Effect of meteorological factors indicated environment significantly affected disease incidence and severity of stripe rust through its impact on development rate of the pathogen. Genotypes having unalike response against stripe rust were investigated to relate the response of stripe rust with epidemiologic factors (temperature, relative humidity, and rainfall). Findings of research exposed same cultivars responded differently under distinct atmospheric circumstances. Fluctuations in environment disturb natural circumstances in farming system; hence affect diseases development in flora. Generally, hostile effect of climate changes i.e. failing the ecosystem apparatuses that control the equilibrium of plant pests and ailments, failing the plant resistance and the development of ecological circumstances favor plant pests and diseases growth. The predisposed genotypes and convenient natural situations contribute towards rust diseases in widespread form. Prediction of future requirements in disease management is of great curiosity. The data generated will be advantageous in disease management with regard to timing, preference and effectiveness of disease control measures and their utilization within integrated pest management (IPM) strategies.

AUTHORS' CONTRIBUTION

AA and MI conceptualized the idea and designed the studies, AA, SA and HN did experimental work and collected data, AA, JI and RA contributed in paper writing, SS prepared graphs and carried out statistical analysis, AA edited the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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