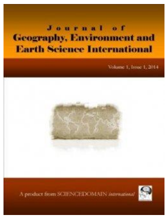

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Wheat Stripe Rust and Its Geospatial Variation in the Jhelum District of Pakistan

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SSA and SI designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author RU managed the literature searches and author TA performed the Hotspot analysis and managed the experimental process and author MN identified the species of plant in the field. All authors read and approved the final manuscript.

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ABSTRACT

Foliar rust disease is a real threat to the wheat crop of Pakistan from few last years. Humid conditions are very favorable for the proliferation of the stripe rust especially in the rain-fed region of the Punjab. This piece of research is done to find the hotspots of the stripe rust in the Jhelum district. Two surveys were conducted for the primary and secondary data collection. Thirty two samples were collected. Threshold values were obtained by using ArcGIS 10.2 application to generate baseline hotspot maps. No one village or district could be highlighted as hot or cold spot, as it changes every year. Increased temperature and heavy rainfall played a very crucial role in spreading of this disease. Intensity of rainfall ranges from 94.6%-140% in month of February which highly thrives the stripe rust by providing moist conditions. Optimal temperature range for wheat crop growth was found as 12°C to 25°C. Hailstorms also badly inflicted damage to the wheat crop especially at some places at the Dina tehsil of Jhelum district.

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Keywords: Crop; disease Incidence; hotspot analysis; temporal analysis.

1. INTRODUCTION

Pakistan is an agricultural country, blessed with fertile soil and optimal climatic conditions for the variety of crops and plants. Its climate is favorable for both Rabi and Kharif crops. The most important Rabi crop is wheat crop as a staple food in this region. There are mainly thirty different wheat varieties being cultivated, out of which some are high yielding while others have low yields [1-3]. Yield of wheat crop in Pakistan has been decreasing from many years due to some abiotic and biotic factors. Abiotic factors constitute the changing climatic conditions while biotic factors include fungi, viruses, nematodes and some bacterial agents [4]. In 2014, estimated yield loss was about 25.33 million tons of wheat especially in KPK province of Pakistan. This study was based on the stripe rust disease or yellow rust of the wheat crop in the Jhelum district (includes in rain-fed region of Punjab) of Pakistan. It is widely spreading disease especially in the rain-fed areas of Punjab. This is an air-borne disease caused by *Puccinia striiformis* and show symptoms as yellow pustules stripes on the leaves and heads of the plant [5]. Climatic conditions are very important in the stages of wheat growth namely germination, growing period and the latent period. Abnormal variations in temperature, precipitation rate, humidity and wind play key roles in the production of diseases [6,7]. Reilly reported in his study that those regions which are having higher temperature ranges are more susceptible to the fluctuation in the optimum temperature which is required for the crop growth [8].

Geographical Information System (GIS) is a vast field, provides a platform to relate ground coordinates with some spatial database like diseases, trends or any other pattern prevalent in that particular area. It is widely used in the crop assessment and its management [9]. In this study, hotspot analysis tool and incremental spatial autocorrelation were used to identify the threshold values and hot or cold spots of yellow rust by using ArcGIS 10.2.

2. MATERIALS AND METHODS

This study has a major focus on finding the hotspots for yellow rust disease in the Jhelum district of Punjab. Two types of data were collected; primary and secondary. Ground truth values and disease data for 2014 was collected as primary data while secondary data includes guide map, climate date and the disease data for the year 2010-14.

2.1 Calculation of Disease Incidence

Incidence of the yellow rust was used to find the percentage of the disease in the whole crop. Sample points were collected in diagonal pattern in the field.

Incidence of the disease was calculated by using the following formula [10]:

Incidence (%) =

$$\frac{(Foliar\ in\ class\ 1) + (foliar\ in\ class\ 2) + (foliar\ in\ class\ 3)}{Total\ foliar\ in\ samples} \times \frac{100}{3}$$

Field was equally divided in 3 parts or classes for incidence calculation. It can be divided in more classes then according formula changes.

2.2 Temporal Analysis

Temporal patterns were observed between the yearly temperature, humidity and precipitation data and the foliar rust diseases. Bi-variable correlation (Pearson's correlation) was used to correlate the yearly climate data and the foliar rust disease.

2.3 Incremental Spatial Auto Correlation (Global Moran's I Statistics)

It is mainly used to spatially correlate the disease points and to find their clustered or dispersed or random pattern on the globe. The Moran's I statistics for spatial autocorrelation is similar as the Pearson's correlation statistics [11-13].

2.4 Hotspot Analysis

In spatial distribution, the condition of clustering is called hotspot [14]. Each characteristics of the input feature class is manipulated and it's *P*-value and z-score are calculated by using 'hotspot analysis tool' in ArcGIS 10.2.

3. RESULTS AND DISCUSSION

3.1 Disease Assessment

Visual assessment of the stripe rust includes severity and prevalence. The data gathered in visual assessment was also beneficial in the incidence calculation of the disease. This data of the disease was further required in the autocorrelation and hotspot analysis. Disease incidence of the stripe rust in the Jhelum district was calculated as shown in Table 3.1.

3.2 Temporal Analysis

Temporal analysis was used to find the temporal variation of yearly temperature, precipitation and humidity with stripe rust disease of the Jhelum district as shown in Fig. 3.1 independent climatic variables were plotted with the stripe rust disease incidence.

Fig. 3.1 shows that the stripe rust is especially significant with the maximum temperature. Increasing temperature provides the optimum proliferation conditions for the stripe rust. Table 3.2 also shows the relation of yearly temperature, humidity and precipitation with the stripe rust disease incidence by using SPSS software.

Table 3.2 shows the positive relation of the temperature with the stripe rust. Temperature has significant statistical value in association with the temperature. Bi-variable correlation was used to find the correlation of the independent variable with the dependent variable.

3.3 Incremental Spatial Autocorrelation

Incremental spatial autocorrelation tool mainly used to measure the spatial distances in the aggregated incident data. The input feature class must have variable values; its script does not run if all the values have 1. Moran's I statistics was used to increment these spatial distances. The tool calculated z-score and the *P*-value by

Table 3.1. The stripe rust disease incidence of the Jhelum district for year 2010, 2011, 2012, 2013 and 2014

S/N	Place	2010	2011	2012	2013	2014
1	Kandwal	22	40	12	5	35
2	Langar	25	42	14	5	35
3	Dhok Gondal	24	45	15	5	42
4	Choran	25	45	10	10	65
5	Khewra	20	50	20	12	70
6	Gharibwal	10	65	30	12	45
7	Haranpur	12	60	25	13	45
8	Chak Danial	15	65	28	15	30
9	Shakarpur	18	55	20	5	30
10	Wagh	20	50	20	8	60
11	Matarial	14	45	10	10	60
12	Qadirpur	13	70	15	8	60
13	Ruhamati	14	80	10	15	65
14	Hamwala	15	65	8	20	75
15	Dariala	17	75	14	15	30
16	Mal	16	80	12	15	35
17	Mohra Mothan	20	80	12	15	40
18	Fatehpur	19	70	15	10	40
19	Raipur	18	65	20	8	65
20	Thalla	17	40	22	5	65
21	Rasulpur	16	45	25	5	70
22	Sultan	10	45	30	10	30
23	Dhok Gujra	12	50	30	20	35
24	Kalan	12	70	30	18	35
25	Jandot	12	75	28	15	35
26	Ratial	13	65	25	10	50
27	Salli	15	50	15	10	60
28	Sagri	16	55	18	5	65
29	Rihana Jattan	20	45	12	5	30
30	Dhok Khingriala	18	40	10	10	30
31	Chhaja	16	55	18	15	35
32	Chak Nalla	14	50	15	10	35

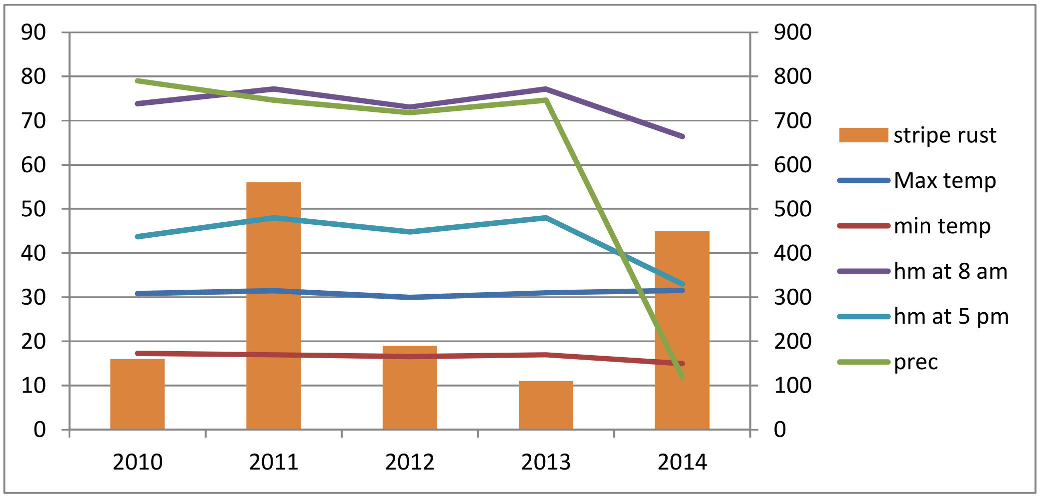

Fig. 3.1. The temporal analysis of the stripe rust of Jhelum district with independent climatic variables

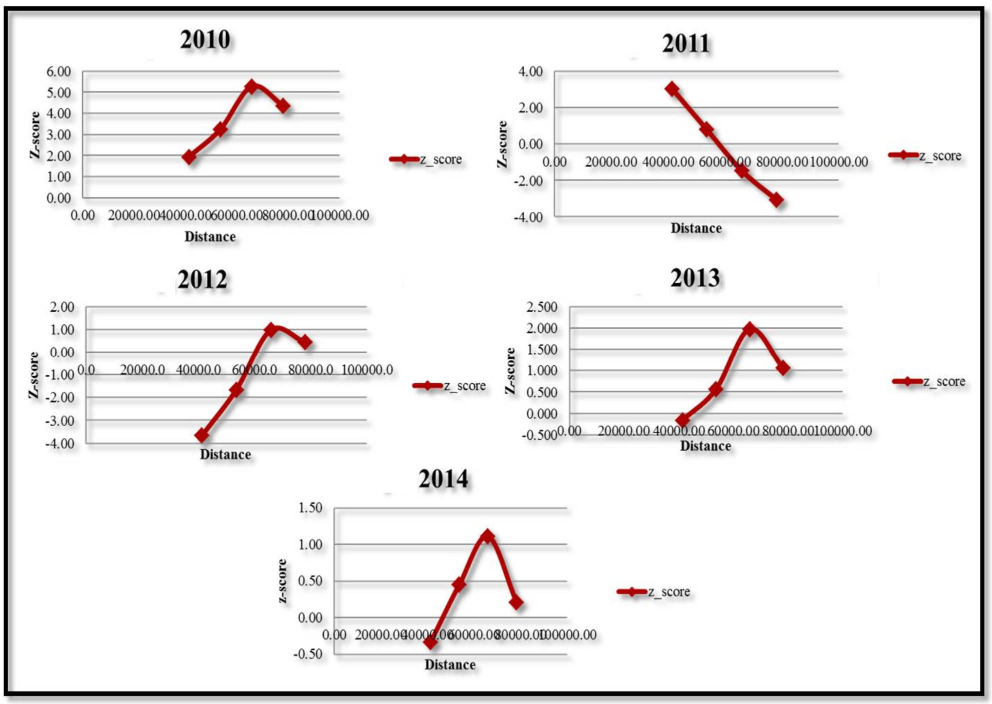

Fig. 3.2. The spatial autocorrelation of the stripe rust in the Jhelum district for year 2010 to 2014

computations the data. As output, the autocorrelation's table is obtained; optionally line graph is also made. Peak values are the values having higher z-score and as a threshold distance for many other parameters. Fig. 3.2 shows the incremental spatial autocorrelation of the stripe rust of the Jhelum district for year 2010 to 2014.

Fig. 3.2 shows that the high peak was obtained in year 2010. Low *P* value and the high z-score promoted to get high peak in the graph. More than one peak can also be obtained, any peak value can be used according to the corresponding parameter, but first peak is the most significant one.

3.4 Hotspot Analysis

The Getis-OrdGi* statistics was used in the hotspot analysis. High or low clustering depends upon the values of z-score and *P* values. The *P* value and *Z* score were itself calculated by the hotspot tool and placed in the output feature class automatically. Spatial clustering by using this tool was more pronounced as compared to the random interpolation. Fig. 3.3 shows the hot and cold spots of the stripe rust in the Jhelum district for year 2010, 2011, 2012, 2013 and 2014.

Fig. 3.3 shows the hot and cold clusters on the basis of statistically calculated z-score and *P* value. High z-score promoted more clustering, and value near zero shows the less or no clustering. For a year 2011, highest the z score indicated more disease. These results highlighted the 2011 as the hot year as previously indicated in the temporal analysis.

In the case of stripe rust on wheat crop in Jhelum district, the minimum incidence was 10% and maximum was 25% in 2010. In 2011, the minimum incidence was 40% and the maximum was 70%. In 2012, the minimum incidence was 10% and maximum was 30%. In 2013, the minimum incidence was 5% and the maximum was 15%. In 2014, the minimum incidence was 30% and the maximum was 70%. The years 2011 and 2014 were the most disastrous years for the wheat crop in Jhelum district with reference to stripe rust.

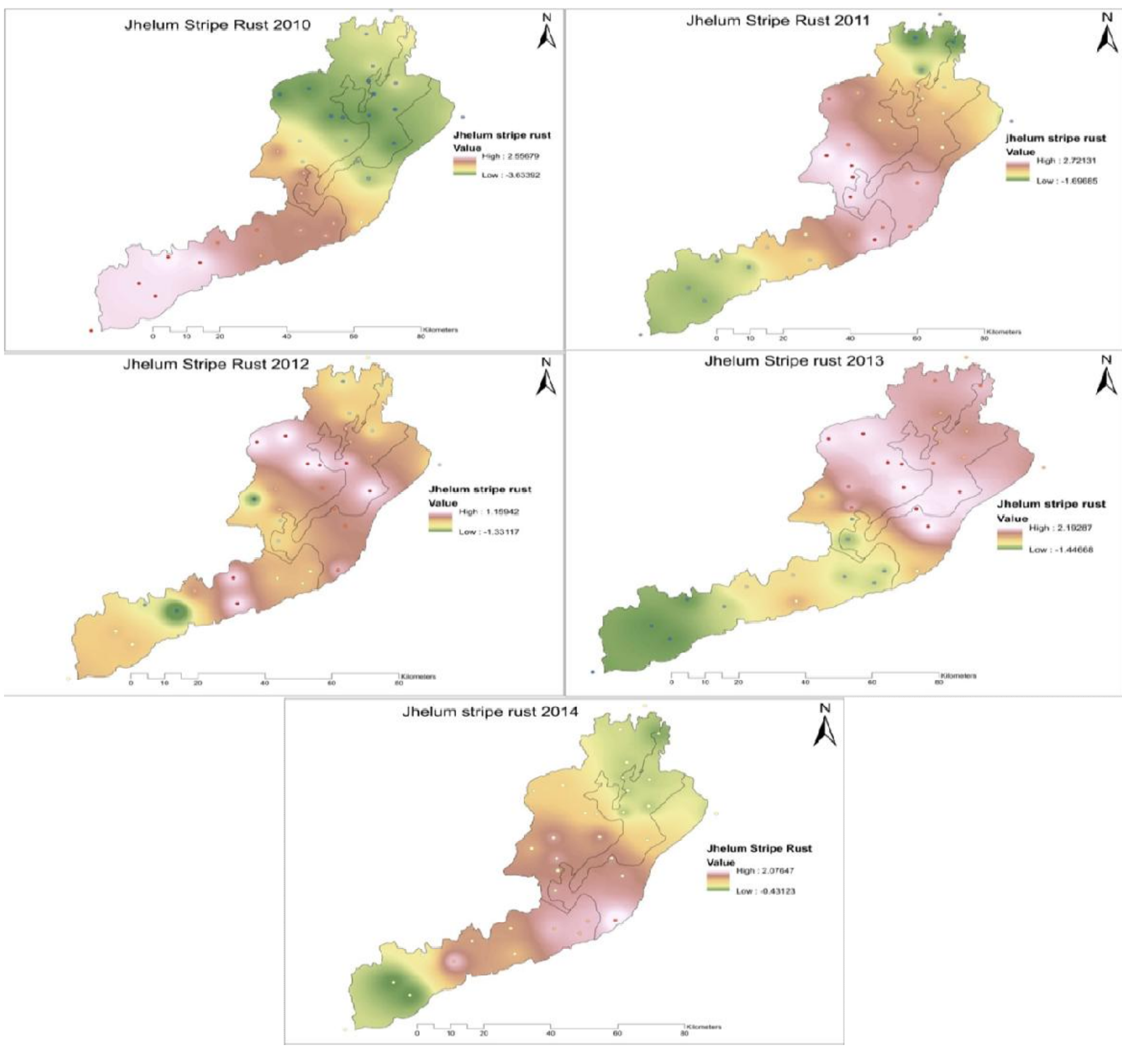

Fig. 3.3. Cold and Hot spots of the stripe rust in the Jhelum district for year 2010 to 2014

Table 3.2. The pearson's correlation of the yearly temperature, humidity and precipitation with the stripe rust incidence

	Temperature	Humidity	Precipitation	Stripe
Temperature		.230	.041	.012
Humidity	.230		.097	.078
Precipitation	.041	.097		.048
Stripe	.012	.078	.048	

4. CONCLUSION

Present study was conducted to find the hot and cold spots of the widely spreading foliar rust disease. Baseline study was proposed by finding global/spatial pattern of the disease on the basis of spatial disease data. The result revealed the statistically significant incremental distances of possible high or low clustering, on the basis of which hotspots were found. Disease was found blowout in almost whole of the districts, as it is an air-borne disease and the wind could move it from one point to another easily. Not a single village or the tehsil remained as hotspot for all the years. Rather, every year it was a different place which proved a hotspot or cold spot. Temporal variation of the stripe rust helped to find its relation with climatic variables. Pearson's correlation also proved the disease dependence on the climatic variables. Temperature was favorable for stripe rust which shows that the disease was increasing in that temperature range.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Iftikhar S, Asad S, Anjum M, Iftikhar I, Amir S. Prevalence and distribution of foliar blights pathogens of wheat in different agro-ecological zones of Pakistan with special reference to *Bipolaris sorokiniana*. Pak. J. Bot. 2006;38:205-210.
2. Asad S, Sultan A, Iftikhar S, Munir A, Ahmad I, Ayub N. Pathogenic diversity in *Bipolaris sorokiniana* isolates collected from different wheat growing areas of the Punjab and NWFP of Pakistan. Pak. J. Bot. 2007;39(6): 2225-2231.
3. Iftikhar S, Asad S, Rattu A, Fayyaz M, Khanzada K. Spot blotch of wheat in different agro-ecological zones of Pakistan. Pak. J. Bot. 2010;42:2139-2144.
4. Singh RP, Huerta-Espino J, Roelfs AP. The wheat rusts. In Bread wheat Improvement and production. BC Curtis, S Rajaram, H. Góme Macpherson, eds. Agriculture Department of the United Nations. 2002; 227-248.
5. Chen XM. Epidemiology and control of stripe rust *(P. striiformis f.* sp. tritici) on wheat. Can. J. Plant Pathol. 2005;27:314-337.
6. Devallavieille PC, Huber L, Leconte M, Bethenod O. Pre inoculation effects of light quantity on infection efficiency of *Puccinia striiformis* and *P. triticina* on wheat seedlings. Phytopathol. 2002;92:1308-1314.
7. Wiik L, Ewaldz T. Impact of temperature and precipitation on yield and plant diseases of winter wheat in southern Sweden 1983–2007. Crop Prot. 2009;28:952–962.
8. Reilly, John. Agriculture in a Changing Climate: Impacts and Adaptations. In IPCC (Intergovernmental Panel on Climate Change), Watson R, M Zinyowera, R Moss, D Dokken, eds. Climate Change 1995: Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses, Cambridge University Press: Cambridge; 1996.
9. Stein A, Kocks CG, Zadoks JC, Frinking HD, Ruissen MA, and Myers DE. A geostatistical analysis of the spatiotemporal development of the downy mildew epidemics in cabbage. Phytopathol. 1994;84:1227-1239.
10. Rattu AR, AsadS, Fayyaz M, Zakria M, Iftikhar S, Ahmad Y. Status of foliar

diseases of wheat in Punjab, Pakistan.Mycopath. 2011; 9(1): 39-42.

11. Boots BN, Getis A. Point pattern Analysis Nexbury Park. Newbury Park, CA, USA: Sage Publications; 1998.
12. Fang L, Yan L, Liang S, Vlas SJD, Feng D, Han X, Zhao W, Xu B, Bian L, Yang H, Gong P, Richardus JH, Cao W. Spatial analysis of hemorrhagic fever with renal syndrome in China. BMC Infectious Diseases. 2006;6:77-88.
13. Cliff AC, Ord JK. Spatial Autocorrelation London: London, UK: Pion Limited; 1973.
14. Osei FB and Duker AA. Spatial and demographic patterns of Cholera in Ashanti region-Ghana. Int J of Health Geographics. 2008;7:44-54.

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