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Madho Singh
Department of Agricultural Meteorology, CCS HAU, Hisar, Haryana, India

Ram Niwas
Department of Agricultural Meteorology, CCS HAU, Hisar, Haryana, India

ML Khichar
Department of Agricultural Meteorology, CCS HAU, Hisar, Haryana, India

Premdeep
Department of Agricultural Meteorology, CCS HAU, Hisar, Haryana, India

Mukesh Kumar Nayak
Department of Agricultural Meteorology, CCS HAU, Hisar, Haryana, India

Nisha Rani
Department of Computer Science, GJUS &T, Hisar, Haryana, India

Corresponding Author:
Madho Singh
Department of Agricultural Meteorology, CCS HAU, Hisar, Haryana, India

Progression of yellow rust disease and AUDPC in North West India

Madho Singh, Ram Niwas, ML Khichar, Premdeep, Mukesh Kumar Nayak and Nisha Rani

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Abstract
The survey was conducted during *Rabi* seasons of 2015-16 and 2016-17 at different locations of NW India, at Department of Agricultural Meteorology, CCSHAU, Hisar (Haryana). Yellow rust severity was recorded at 15 days intervals. Disease severity was recorded higher (70%) during *Rabi* 2015-16 as compared to 2016-17 (60%). In North-West India yellow rust disease was appeared at Yamuna Nagar on 9th January (2nd SMW) followed by Dhaula Kuan 13th January (2nd SMW) during 2015-16 and yellow rust disease appeared at Gurdaspur on 29th December (52nd SMW) followed by Yamuna Nagar on 20th January (3rd SMW) during 2016-17. The value of AUDPC was higher in Gurdaspur (Punjab) followed by Dhaula Kuan (Himachal Pradesh) and minimum value was in Hisar (Haryana)during the 2015-16 and during the 2016-17, AUDPC value was maximum in Jammu (Jammu & Kashmir) followed by Gurdaspur (Punjab) and minimum value was in Hisar (Haryana).

Keywords: Yellow rust disease, stripe rust, wheat, AUDPC, *Puccinia striiformis*, progression of yellow rust, disease severity

Introduction
With the current global situation requiring higher wheat production from declining land areas, more productive farming systems will potentially increase pressure from diseases such as stripe rust or yellow rust. Wheat crop in certain parts of Punjab, Haryana, Jammu& Kashmir and parts of Uttarakhand and bordering crop fields in Uttar Pradesh are affected by stripe rust or yellow rust. Yellow rust of wheat caused by a fungal pathogen, *Puccinia striiformis* probably occurred long before wheat was grown for food, whereas, Gadd from Europe first described it in 1777 (Eriksson and Henning 1896) [3]. The stripe rust pathogen is favoured by long mild winter, wet and cool spring season. This disease appears if cold temperature with intermittent rains prevails during the months of February and March. Wind is the main means of spread or dispersal of stripe rust. Huerta-Espino *et al.*, (2011) [5] reported that *Puccinia triticina* has a wide virulence range and is broadly adapted to diverse climatic conditions, leading to regular and significant yield losses over large geographical areas. In most wheat-producing areas, yield losses caused by yellow rust have ranged from 10 to 70 per cent depending on susceptibility of the cultivar, earliness of the initial infection, rate of disease development, and duration of disease (Chen, 2005) [2]. The yellow rust disease responsible for loss of the tune of Rs. 236 crores in Punjab (Jindal *et al*. 2012) [6].

Materials and Methods
The locations selected from NW India were Jammu (Jammu & Kashmir), Gurdaspur (Punjab), Ballowal Saunkhari (Punjab), Dhaula Kuan (Himachal Pradesh), Yamuna Nagar (Haryana), Ambala (Haryana), Karnal (Haryana) and Hisar (Haryana). Stripe rust severity was recorded visually as the percentage of leaf area infected according to the modified Cobb's or Peterson's scale (Peterson *et al.*, 1948) [8]. The disease was recorded on 10 randomly selected plants and per cent plants affected by the disease were recorded at 15 days intervals. Severity index was calculated by using the following formulae:

$$\text{Severity index (\%)} = \frac{\text{Area of plant tissue infected x10}}{\text{Total area of plant}} \text{ X } 100$$

Area under disease progressive curve (AUDPC)

The area under the disease progress curve (AUDPC) is a useful quantitative summary of disease intensity over time, for comparison across years, locations, or management tactics. The most commonly used method for estimating the AUDPC, the trapezoidal method, is to discretize the time variable (hours, days, weeks, months, or years) and calculate the average disease intensity between each pair of adjacent time points (Madden *et al.* 2007).

$$AUDPC = \Sigma_{i=1}^{n} 1/2 (Yi - Yi\text{-}1) (Xi - Xi\text{-}1)$$

Where,
Yi = Rust severity at the ithobservation,
Xi = Time (d) of ithobservation,
n = total number of observations, and
Yi-1= Disease severity at previous observation on Xi-1 day.

Global positioning System

A Global Positioning System (GPS) was used to locate the graticules of infected field of wheat at different sites for further analysis. GARMIN (ORGEON 605) GPS receiver was used in the present study. Generation of yellow rust severity map were prepared in the GIS environment using ARC info 10.4.

Generation of yellow rust severity map In GIS

NDVI and yellow rust disease severity maps were prepared in the GIS environment using ARC info 10.4. Following steps were followed to prepare the maps:

- Jammu & Kashmir, Punjab, Himachal Pradesh and Haryana state polygon coverage was selected.
- X, Y coordinates (latitude and longitude) of the observation sites were found using GPS.
- The latitude and longitude data were converted to degree-decimal format. 19
- The coverage file (point) was then generated from the location data in Arc info GIS.
- The NDVI and disease severity data were transferred to attribute table and attached to the point file coverage already generated.
- The point file coverage was converted to raster format.

Results and Discussion

Disease severity

The progression of yellow rust disease in NW India during season 2015-16 is presented in Map1. Yellow rust disease was appeared at Yamuna Nagar on 9th January (2nd SMW) with disease severity of 5 per cent followed by Dhaula Kuan on 13th January (2nd SMW) with same disease severity. Thereafter, yellow rust disease was appeared in Gurdaspur on 17th January (3rd SMW) with disease severity of 5 per cent. Further, yellow rust was appeared in Jammu on 19th January (3rd SMW) with disease severity of 10 per cent. Finally, yellow rust was appeared in Ambala, Karnal and Hisar on 30thJanuary, 2nd February and 8th February, respectively.

It is evident from the recorded observations that the maximum disease severity of yellow rust was in Yamuna Nagar station i.e.70 per cent in the end of February followed by Gurdaspur and Jammu 60 percent at the end of February. And minimum disease severity of yellow rust was recorded at Hisar station 20 per cent in end of February. This might be due to reason that inoculums remains in foot hills of Himalaya during off season and spread in plains by air as the favorable weather prevails. During 2010–2011, stripe rust appeared in severe form in plain areas in Jammu &Kashmir, foot hills of Punjab and Himachal Pradesh, parts of Haryana, and tarai regions of Uttarakhand (Sharma and Saharan, 2011) [11]. Recently, stripe rust has gained importance in India particularly in North Western Plain Zone (NWPZ) and Northern Hills Zone (NHZ) (Prashar *et al*., 2007; Saharan *et al*., 2013) [9, 10].

The progression of yellow rust disease during season 2016-17 is presented in Map 2. Yellow rust disease appeared at Gurdaspur on 29th December (52nd SMW) with disease severity of 5per cent followed by Yamuna Nagar on 20th January (3rd SMW) with 10 per cent disease severity. Thereafter, yellow rust disease appeared in Jammu on 23th January (4thSMW) with disease severity of 10 per cent. Further, yellow rust progressed in Dhaula Kuan on 7th February (6th SMW) with disease severity of 10 per cent. Finally, yellow rust appeared in Ambala, Karnal and Hisar on 8th February, 10th February and 12th February, respectively. It is evident from the map the maximum disease severity of yellow rust was recorded at Gurdaspur station i.e. 60 per cent followed by Jammu and Yamuna Nagar with 50 percent disease severity at the end of February month. And minimum disease severity of yellow rust was recorded at Hisar station 20 per cent in end of February month.

Area under disease progress curve

The area under the disease progress curve is a useful quantitative summary of disease intensity over time, for comparison across years, locations, or management tactics Area under disease progressive curve of all the locations of NW India are presented in Table 1 and Table 2 for 2015-16 and 2016-17, respectively. The area under the disease progress curve ranged from 35 to 1377.5 and 45 to 735 during the year 2015-16 and 2016-17, respectively. During the 2015-16, the value of AUDPC was higher in Jammu followed by Dhaula Kuan and minimum value in Hisar. During the 2016-17, AUDPC value was maximum in Jammu followed by Gurdaspur and minimum value was in Hisar, this might be due to lower infection was recorded in Hisar. Similar results were reported by Gupta *et al*. (2013) [4] and Arora *et al*. (2014) [1].

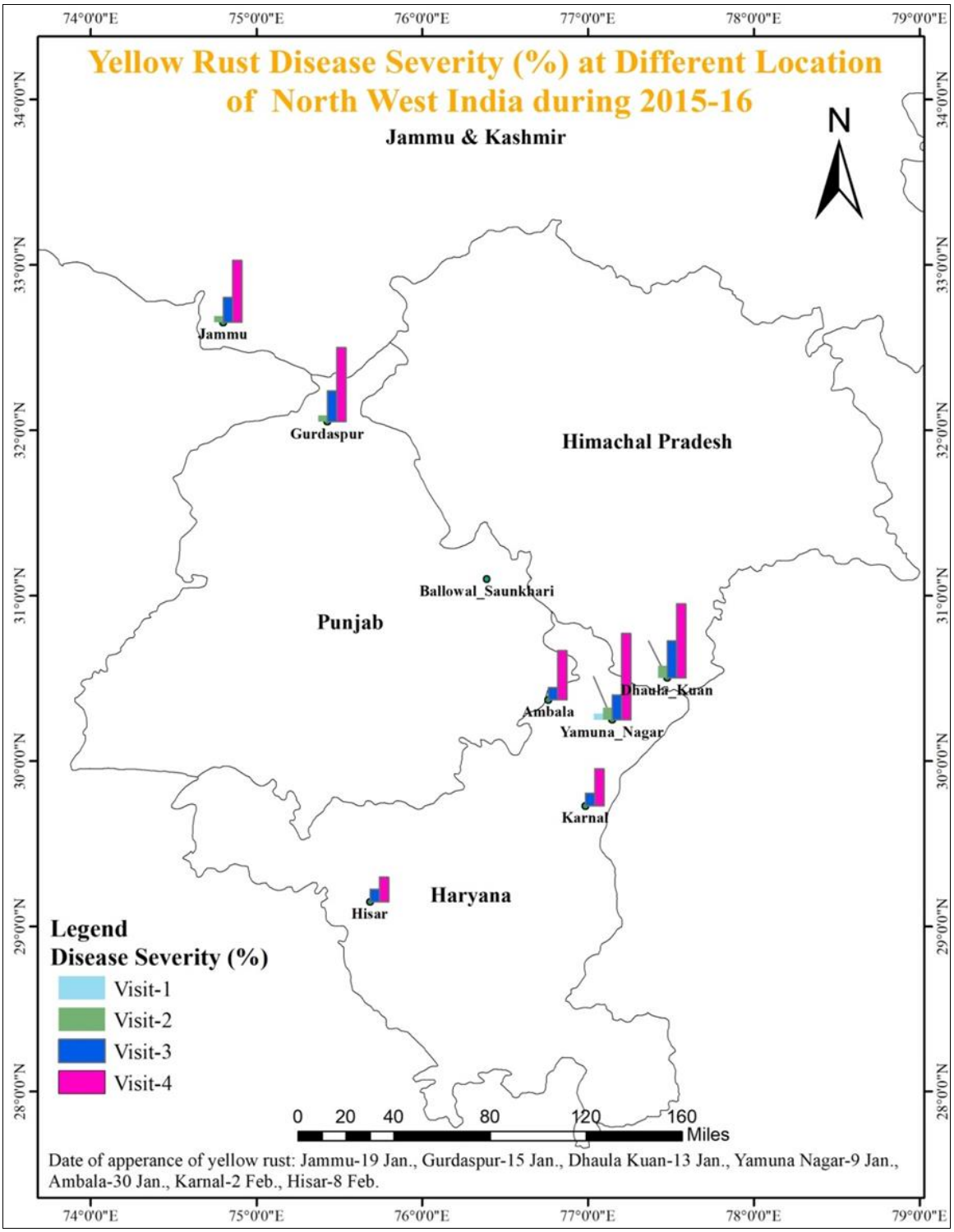
Table 1: Area under Disease Progress Curve at different locations of NW India during 2015-16

Station Name	Visit 1 (1-15 Jan)	Visit 2 (15-31 Jan)	Visit 3 (1-15 Feb)	Visit 4 (16Feb to 05 Mar)
Jammu	0	40	212.5	805
Gurdaspur	0	35	195	1377.5
Dhaula Kuan	0	75	280	1260
Yamuna Nagar	35	120	260	1050
Ambala	0	0	95	425
Karnal	0	0	85	340

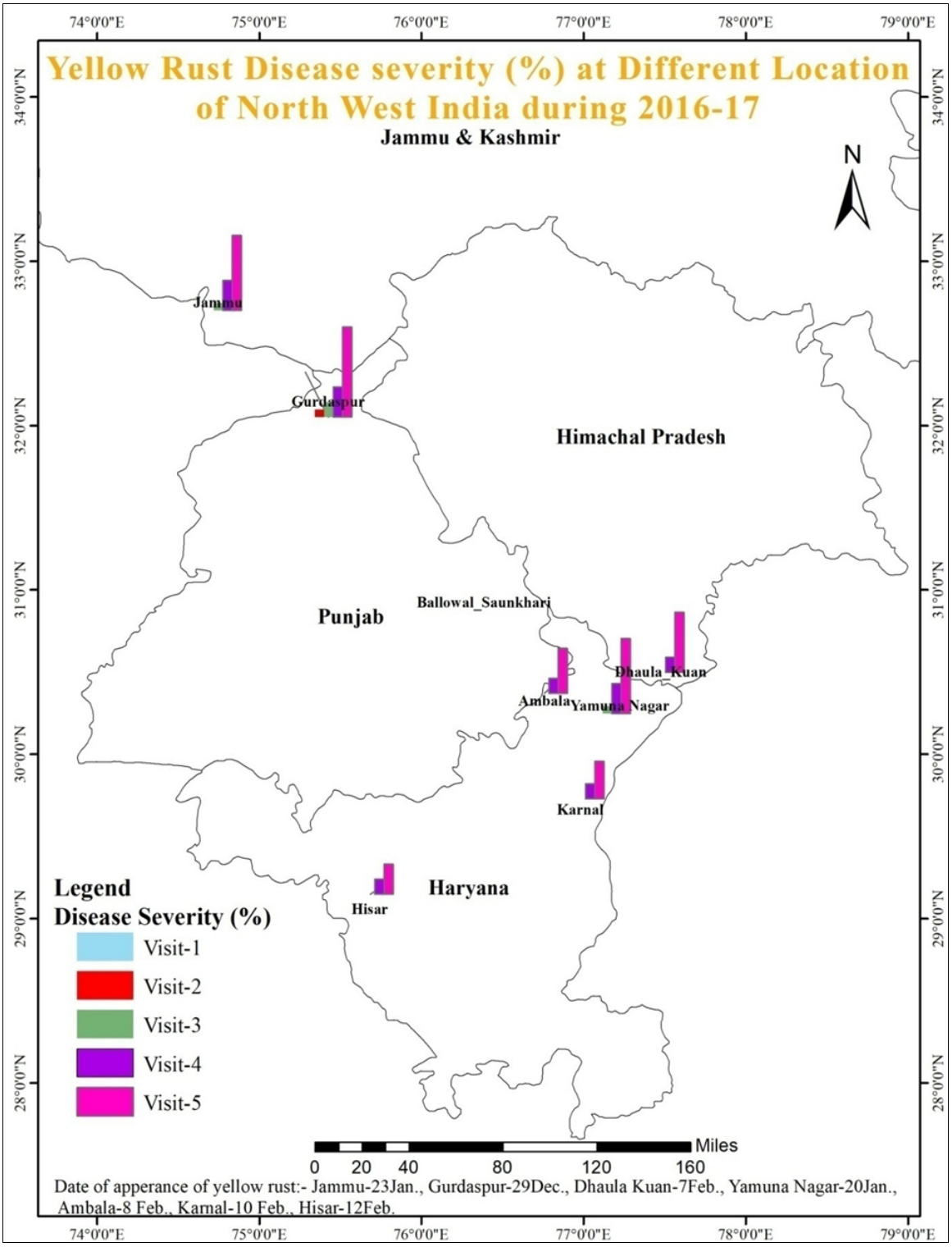
Hisar	0	0	75	270

Table 2: Area under Disease Progress Curve at different locations of NW India during 2016-17

Station Name	VISIT 1 (16-31 Dec)	VISIT 1 (1-15 Jan)	VISIT 2 (15-31 Jan)	VISIT 3 (1-15 Feb)	VISIT 4 (16 Feb to 05 Mar)
Jammu	0	0	52.5	262.5	735
Gurdaspur	0	45	105	330	680
Dhaula Kuan	0	0	0	80	375
Yamuna Nagar	0	0	35	175	490
Karnal	0	0	0	75	240
Ambala	0	0	0	90	220
Hisar	0	0	0	110	210



Map 1: Yellow rust disease severity (%) at different location of North-West India during 2015-16.



Map 2: Yellow rust disease severity (%) at different location of North-West India during 2016-17.

Conclusion

These results indicate that yellow rust generally appeared in the month of December, and January in the sub-mountainous area of Punjab and Haryana and then progressed further in plains of Haryana. Results revealed that the disease severity remained low in the year of 2016-17 as compared to 2015-16. The value of AUDPC was higher in Jammu and minimum value in Hisar during the 2015-16, and during the 2016-17, AUDPC value was also higher in Jammu and minimum value was in Hisar.

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