Correlation of date of sowing and weather factors on the disease progression of Alternaria blight of Niger

Shikha Sharma, RS Ratnoo and HK Jain

Keywords: Correlation, date of sowing, weather parameter, disease intensity

Introduction
Niger [Guizotia abyssinica (L.f.) Cass.] is commonly known as ramtil, jagni or jatangi (Hindi). Among the other disease of Niger, Alternaria blight (Alternaria spp.) and leaf spot are the most serious and devastating. It is caused by Alternaria porri (Ell.). Alternaria alternata has also been reported to cause leaf bight of Niger from India (Kolte, 1985) \[5\]. The disease is favoured by warm and humid climate. Further, the accidental rain at flowering stage leads the expansion of Alternaria leaf spot incidence and results in the poor seed set and seed yield. Diseases cause heavy damage upto 35-40% to this crop and reduce its seed yields upto 25-30%, which harm the status of the farmers. Therefore, the experiment was conducted to find out the effect of date of sowing and role weather factors on the development of disease on susceptible Niger cultivar IGP-76.

Materials and methods
The experiment was conducted to find out the effect of date of sowing on the development of Alternaria blight disease on susceptible Niger cultivar IGP-76 and staggered sowing was done from 21\textsuperscript{st} June and dates 21\textsuperscript{st} June were as followed, 30\textsuperscript{th} June, 7\textsuperscript{th} July, 15\textsuperscript{th} July,21\textsuperscript{st} July, 30\textsuperscript{th} July in the year 2013 and 2015. After germination 15-days-old plants were inoculated on 6\textsuperscript{th} July, 15\textsuperscript{th} July, 22 July, 30 July, 6\textsuperscript{th} August, 15\textsuperscript{th} August with a spore suspension of 1×10\textsuperscript{7} conidia ml\textsuperscript{-1}. Latent period from initiation and disease severity calculated at interval of 15 days following the 0-5 scale. Weather variables viz., temperature, RH, sunshine hours, rainfall, wind velocity and evaporation etc. were also recorded for crop season and correlation was worked out.

Percent disease intensity (PDI) was calculated based on each reading till maturity of crop. Weekly meteorological data on maximum and minimum temperature morning and evening relative humidity, rainfall and duration of sunshine hours, wind velocity and evaporation were obtained from agromet observatory, Agronomy farm RCA, Udaipur for the period between Kharif, 2013 and 2015 and disease was recorded to establish their correlation with disease development. Area under disease progressive curve (AUDPC) values were calculated for different recording by the formula given by Campbell and Madden (1990) \[3\]. Sequential apparent infection rate was calculated between two subsequent observations. AUDPC and r, was calculated by the method described by Vander Plank (1963) \[8\], later described by Campbell and Madden (1990) \[3\] as follows:
where

\[ r_c = \frac{1}{2} \log \frac{\text{total number of observations}}{\text{total number of covariance}} \]

To study the relationship between eight independent variables (max. temp., min. temp., max. RH, min. RH, wind velocity, sunshine, rain and evaporation) and dependent variables i.e. percent disease index, multiple linear regression analysis was done by fitting this equation.

The analysis (s) is as under:

\[ Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8 X_8 \]  

Where,

\[ R^2 = \text{multiple correlation coefficients}, \]
\[ Y = \text{percent disease index (dependent variable)}, \]
\[ a = \text{constant (intercept)}, \]
\[ b_1, b_2, b_3, b_4, b_5, b_6, b_7, b_8 = \text{partial regression coefficients} \]
\[ X_1 = \text{max. temp.}, X_2 = \text{min. temp.}, \]
\[ X_3 = \text{max. RH}, X_4 = \text{min. RH}, \]
\[ X_5 = \text{wind velocity}, X_6 = \text{sunshine}, X_7 = \text{rain}, X_8 = \text{evaporation} \]

* (X_1-X_8 are independent variable)

Results and discussion

In the year 2013, the relationship between the abiotic factors viz., max. temp., min. temp., max. RH, min. RH, wind velocity, sunshine, rain and evaporation with percent disease index (PDI) was examined with the Pearson’s coefficient of correlation. The calculated value showed a significant and positive correlation between percent disease index and max. RH (\( r = 0.527^* \)), wind velocity (\( r = 0.582^* \)), sunshine (\( r = 0.045^* \)) with positive correlation with maximum temperature (\( r = 0.463 \)), minimum temperature (\( r = 0.336 \)), min RH (\( r = 0.209 \)), and rain (\( r = 0.106 \)). Whereas, significant and negative correlation between percent disease index and evaporation (\( r = -0.563^* \)), was clearly implies that high temperature, RH, wind velocity, sunshine and rain has significant and positive impact on the PDI (Table-1).

Further, during the year 2015, positive correlation between PDI and maximum temperature (\( r = 0.346 \)), minimum temperature (\( r = 0.389 \)), max. RH (\( r = 0.1335 \)), min RH (\( r = 0.1112 \)), wind velocity (\( r = 0.5341^* \)), sunshine (\( r = 0.0292^* \)), rain (\( r = 0.0536 \)) was observed. Whereas, evaporation has negative correlation (\( r = -0.6722^* \)). Thus in both the years under study it was found that increase in these abiotic factors (weather parameters) had significant impacts on the PDI. (Table-3)

Multiple linear regression analysis

To know the relationship between the disease severity (dependent variable) and the weather factors (maximum temperature, minimum temperature, maximum percent relative humidity and minimum percent relative humidity) multiple linear regression analysis and for sunshine correlation coefficient analysis was done with 21\(^{st}\) July sown plants. By fitting this equation, the contribution of weather factors in the development of Alternaria leaf spot was observed.

In order to find out the relative contribution of independent variables (abiotic factors) on dependent variable (PDI), the technique of multiple linear regression analysis was computed. The predictive power of multiple regressions was estimated by working out the value of coefficient of determination (R\(^2\)).

For the year 2013

\[ Y = 474.03 + 9.11 X_1 - 22.65 X_2 - 11.42 X_3 + 15.24 X_4 - 25.53 X_5 + 45.95 X_6 - 1.43 X_7 - 26.02 X_8 \]  

The fitted multiple regression equation (2013) is as under:

The data presented in above equation, reveals that eight independent variables viz., max. temp., min. temp., max. humidity, min. humidity, wind velocity, sunshine, rain and evaporation had a significant contribution to the role of PDI during 2013. Moreover, \( b_1 = 9.11 \) indicates that holding abiotic factors viz., \( X_2 \) (min. temp.), \( X_3 \) (max. RH), \( X_4 \) (min. RH), \( X_5 \) (wind velocity), \( X_6 \) (sunshine), \( X_7 \) (rain), \( X_8 \) (evaporation) constant, 1 degree increase in max. temp. led on the average to about 9.11 percent increase in average percent disease index. On the other hand, \( b_2 =-22.65 \) showed that if keeping other abiotic factors \( X_1 \) (max. temp.), \( X_3 \) (max. RH), \( X_4 \) (min. RH), \( X_5 \) (wind velocity), \( X_6 \) (sunshine), \( X_7 \) (rain) and \( X_8 \) (rain) constant, 1 degree increase in min. temperature led on the average to about 22.65 percent decrease in average percent disease index. As far as the contribution of relative humidity is concern, the value of \( b_3 =-11.42 \) reflects that keeping other weather parameters viz., \( X_3 \) (max. temp.), \( X_5 \) (min. temp.), \( X_6 \) (min. RH), \( X_7 \) (wind velocity), \( X_8 \) (sunshine), \( X_7 \) (rain) and \( X_8 \) (rain) constant, 1 percent increase in max. RH led on the average to about 11.42 percent decrease in average PDI. Likewise, \( b_4 =-15.24 \) showed that keeping other independent variables viz., \( X_1 \) (max. temp.), \( X_5 \) (min. temp.), \( X_7 \) (max. RH), \( X_5 \) (wind velocity), \( X_6 \) (sunshine), \( X_7 \) (rain) and \( X_8 \) (evaporation) constant, 1 percent increase in min. RH led on the average to about 15.24 percent decrease in average PDI. The abiotic factor viz., wind velocity (\( b_5 =-25.53 \)) showed that keeping other independent variables viz., \( X_1 \) (max. temp.), \( X_2 \) (min. temp.), \( X_3 \) (max. RH), \( X_5 \) (wind velocity), \( X_6 \) (sunshine), \( X_7 \) (rain) and \( X_8 \) (evaporation) constant, 1 percent increase in wind velocity led on the average to about 25.53 percent decrease in average PDI. As far as the contribution of sunshine, the value of \( b_6 =45.95 \) reflects that keeping other weather parameters viz., \( X_3 \) (max. temp.), \( X_5 \) (min. temp.), \( X_7 \) (min. RH), \( X_5 \) (wind velocity), \( X_6 \) (sunshine), \( X_7 \) (rain) and \( X_8 \) (evaporation) constant, 1 percent increase in sunshine led on the average to about 45.95 percent increase in average PDI. Likewise, \( b_7 =-1.43 \) showed that keeping other independent variables viz., \( X_1 \) (max. temp.), \( X_2 \) (min. temp.), \( X_3 \) (max. RH), \( X_5 \) (wind velocity), \( X_6 \) (sunshine), \( X_7 \) (rain) and \( X_8 \) (evaporation) constant, 1 percent increase in evaporation led on the average to about 1.43 percent decrease in average PDI. Similarly, \( b_8 =-26.02 \) showed that keeping other independent variables viz., \( X_1 \) (max. temp.), \( X_2 \) (min. temp.), \( X_3 \) (max. RH), \( X_5 \) (wind velocity), \( X_6 \) (sunshine), \( X_7 \) (rain) and \( X_8 \) (evaporation) constant, 1 percent increase in evaporation led on the average to about 26.02 percent decrease in average PDI.

The value of \( R^2 = 0.74 \) indicates that the abiotic factors (weather parameters) are able to explain about 74 percent of
the variation in the percent disease index. The remaining 26 percent of the variation is on account of the variables not considered. The value of F ratio was found significant (F = 3.57) at 1 percent level of significance. Hence, the null hypothesis is rejected and the effect of independent variables (abiotic factors) on dependent variable (PDI) may be taken as significant.

All inoculated plants were periodically observed for disease severity on 0-5 scale and area under disease progressive curve (AUDPC) was calculated. Considerable variations were observed in AUDPC in six different dates of sowing and correlation with weather factors on disease development. In the first sowing on 21st June and inoculated on 6th July, the AUDPC was 11.31, in the next week it was 23.51 and in the third week (42 days old plants) reached to 33.84. The AUDPC in the following 30th weeks ranged from 55.61-100. In the 32nd to 34th week the AUDPC was in high range (190-289). In the 35th to 39th week the AUDPC remained more or less stable while from the 40th to 43rd week AUDPC it was to started declining. In the pot sown on 30th June and inoculated on 15th July, the AUDPC in the first week after inoculation disease severity was 10.27. It progressed slowly upto next 29 week (22nd Aug), it ranged between 25.76-55.69. In the next weeks the AUDPC increased upto by 145 upto 31st week due to rain. In the week of 32nd to 34th week disease severity increased and reached upto highest AUDPC of 282 but after that disease remained slightly constant upto 39th week. From 42nd to 43rd week AUDPC start to decline from 240 to 185 (Table-2).

In the pots sown on 7th July and inoculated on 22nd July and those sown on 15th July and inoculated on 30th July, the AUDPC was 8.88 and 6.78 respectively. It was lower than first two dates sown in the (11.39 and 10.27), July, respectively. It increased to 25.58 and 20.76 respectively on next week and further disease severity increased upto 135.99 and 121.55 in 30th week. Higher AUDPC was recorded in the 34th week (279.98) in the pots sown on 7th July as compared to 266.44 in those sown on 15th July. From 35th to 39th week AUDPC remained more or less constant. After 40th week to 43rd week it went down and reached to 183.55 and 181.76, in 7th and 15th July sown pots. Further the pots sown on 21st July and inoculated on 6th August and also in those sown on 30th July and inoculated on 15th August, the AUDPC was 6.43 and 4.23 respectively. It was again lower than those first two dates sown respectively. It was again increased to 25.58 and 15.71 respectively on next week and further remained increased to 143.44-79.87 upto next 32 weeks. Higher AUDPC was recorded in the 34th week (235.00) in the pots sown on 21st July as compared to 147.54 in those sown on 30th July. From 35th to 39th week AUDPC remained more or less constant than after 40th week to 43rd week it goes down and reached to 179.33 and 111.00 in 21st and 30th July sown pots.

It was observed that the disease progressed faster when the maximum temperature ranged from 29.0 to 32.0 and the age of plant also seemed to be important as disease progress was higher on 40-60 days old plants.

The minimum and maximum temperature range was 21-24 °C and 29-32 °C, accompanied with relative humidity i.e. between 70-88.0 percent, wind velocity more than 4.7 km/hrs, rains and more of sunshine helps in the progress phase of AUDPC value ranging from 100-289 percent disease was found almost stable.

In Year 2015

\[
Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 \quad (R^2)
\]

The fitted multiple regression equation (2015) is as under:

\[
Y = 1508.78-21.24 X_1-6.16 X_2-12.6 X_3 +10.23 X_4-37.24 X_5 +18.72 X_6+0.80X_7+7.3 X_8 \quad (R^2= 81 \text{ percent})
\]

The data presented in above equation, reveals that eight independent variables viz., max. temp., min. temp., max. humidity, min. humidity, wind velocity, sunshine, rain and evaporation had a significant contribution to the role of PDI during 2013. Moreover, b_1 = -21.24 indicates that holding abiotic factors viz., X_1 (min. temp.), X_2 (max. RH), X_3 (min. RH), X_5 (wind velocity), X_6 (sunshine), X_7 (rain) and X_8 (rain evaporation) constant, 1 degree increase in max. temp. led on the average to about 21.24 percent decrease in average percent disease index. On the other hand, b_2 = -.616 showed that if other abiotic factors X_1 (max. temp.), X_2 (min. RH), X_3 (wind velocity), X_6 (sunshine), X_7 (rain) and X_8 (rain evaporation) kept constant, 1 degree increase in min. temperature, led on the average to about 6.16 percent decrease in average percent disease index. As far as the contribution of relative humidity is concern, the value of b_3 = -12.6 reflects that keeping other weather parameters viz., X_1 (max. temp.), X_2 (min. temp.), X_4 (min. RH), X_5 (wind velocity), X_6 (sunshine), X_7 (rain) and X_8 (evaporation) constant, 1 percent increase in max. RH led on the average to about 12.6 percent decrease in average PDI. Likewise, b_4 = 10.23 showed that keeping other independent variables viz., X_1 (max. temp.), X_2 (min. temp.), X_3 (max. RH), X_5 (wind velocity), X_6 (sunshine), X_7 (rain) and X_8 (evaporation) constant, 1 percent increase in min. RH led on the average to about 10.23 percent increase in average PDI. As far as abiotic factor viz., wind velocity is concerned (b_5 = -37.24) showed that keeping other independent variables viz., X_1 (max. temp.), X_2 (min. temp.), X_3 (max. RH), X_5 (wind velocity) X_6 (sunshine) X_7 (rain) X_8 (evaporation) and X_9 (rainfall) constant, 1 percent increase in wind velocity led on the average to about 37.24 percent decrease in average PDI on the increase of average PDI. As far as the contribution of sunshine is concern, the value of b_6 = 18.72 reflects that keeping other weather parameters viz., X_1(max. temp.), X_2 (min. temp.), X_4 (min. RH.), X_5 (wind velocity), X_6 (sunshine), X_7 (rain) and X_8 (evaporation) constant, 1 percent increase in sunshine led on the average to about 18.72 percent increase in average PDI. Likewise, b_7 = 0.80 (rain) showed that keeping other independent variables viz., X_1 (max. temp.), X_2 (min. temp.), X_3 (max. RH), X_5 (wind velocity), X_6 (sunshine), X_7 (rain) and X_8 (evaporation) constant, 1 percent increase in rain led on the average to about 0.80 percent increase in average PDI. Similarly, b_8 = 7.3 showed that keeping other independent variables viz., X_1 (max. temp.), X_2 (min. temp.), X_3 (max. RH), X_5 (wind velocity), X_6 (sunshine), X_7 (rain) and X_8 (evaporation) constant, 1 percent increase in evaporation led on the average to about 7.3 percent increase in average PDI.

The value of R^2 = 0.81 indicates that the abiotic factors (weather parameters) are able to explain about 81 percent of the variation in the percent disease index. The remaining 11 percent of the variation is on account of the variables not considered. The value of F ratio was found significant (F = 5.65**) at 1 percent level of significance. Hence, the null hypothesis is rejected and the effect of independent variables (abiotic factors) on dependent variable (PDI) may be taken as significant (Table 3).

While discussing the pooled data of both the years the multiple linear regression analysis, the factor value of b_1 = 9.11 (2013), b_1 = -21.24 (2015) indicates that holding abiotic factors viz., X_1 (min. temp.), X_2 (max. RH), X_3 (min. RH), X_5 (wind velocity), X_6 (sunshine), X_7 (rain), X_8 (rain) constant, 1 degree increase in max. temp. led on the average to about 9.11
In the pot sown on 7th July and inoculated on 22nd July and also in those sown in 15th July and inoculated on 30th July the AUDPC was 9.88 and 7.78 respectively. It was lower (12.39 and 11.27) respectively than those first two dates sown in the July. It increased to 26.58 and 21.76 respectively on next week. Further disease severity increased upto 86.53 and 61.65 in 30th week. Higher AUDPC was recorded in the 33rd week (280.98) in the pots sown on 7th July as compared to 270.44 in those sown on 15th July. From 35th to 39th week AUDPC remained more or less constant than after 39th week to 43rd week it goes down and reached to 241.43 and 186.66 in 7th July and 265 to 182 in 15th July sown pots respectively. Further the pots sown on 21st July and inoculated on 6th August and also in those sown on 30th July and inoculated on 15th August, the AUDPC was 7.43 and 5.23 respectively. It was again lower than first two date’s sown plants respectively. It was again increased to 26.55 and 16.71 respectively on next week and further increased to 122.87-41.43 respectively, upto next 32 weeks. Higher AUDPC was recorded in the 33rd week (243.44) in the pots sown on 21st July as compared to 180.87 in those sown on 30th July. From 35th to 39th week AUDPC remained more or less constant than after 40th week to 43rd week it goes down from 234 to 180 in 21st and reached to 143 to 112.00 in 30th July sown pots. It was observed that the disease progressed faster when the maximum temperature ranged from 29.0 to 32.00 and the age of plant also seemed to be important as disease progress was higher on 40-60 days old plants.

Results of year 2013 and 2015 revealed similar trends in both the years in all the dates of sowings. As progress slowly in the initial week when plant were too young then disease increased when it got constant temperature range from 29- 32ºC, more than 70 percent relative humidity, more wind velocity, accidential rains, diseases progress reached to highest at 60 days old plant and then remained more or less constant in further next week and afterwards started declining.

### Table 1: Progression of Alternaria blight on Niger in relation to weather parameters with different date of sowing during kharif, 2013

<table>
<thead>
<tr>
<th>Standard week, 2013</th>
<th>Meteorological weeks</th>
<th>Temperature (°C)</th>
<th>Relative Humidity (%)</th>
<th>Wind Velocity (km/hr)</th>
<th>Sunshine (hrs)</th>
<th>Rain (mm)</th>
<th>Evaporation (mm)</th>
<th>AUDPC*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Max.</td>
<td>Min.</td>
<td>I</td>
<td>II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>18 Jun- 24 Jun</td>
<td>33.5</td>
<td>24.3</td>
<td>74.6</td>
<td>51.9</td>
<td>6.6</td>
<td>7.1</td>
<td>4.2</td>
</tr>
<tr>
<td>26</td>
<td>25 Jun -1 July</td>
<td>33.2</td>
<td>25.8</td>
<td>74.40</td>
<td>54.1</td>
<td>8.4</td>
<td>4.1</td>
<td>9.0</td>
</tr>
<tr>
<td>27</td>
<td>2 July - 8 July</td>
<td>32.9</td>
<td>24.8</td>
<td>80.6</td>
<td>62.6</td>
<td>5.8</td>
<td>2.1</td>
<td>12.8</td>
</tr>
<tr>
<td>28</td>
<td>9 July - 15 July</td>
<td>30.7</td>
<td>24.1</td>
<td>81.0</td>
<td>70.1</td>
<td>5.5</td>
<td>1.8</td>
<td>73.4</td>
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<tr>
<td>29</td>
<td>16 July-22July</td>
<td>29.7</td>
<td>24.2</td>
<td>83.6</td>
<td>73.4</td>
<td>4.5</td>
<td>1.5</td>
<td>83.8</td>
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<td>30</td>
<td>23 July-29 July</td>
<td>30.6</td>
<td>23.6</td>
<td>88.1</td>
<td>77.3</td>
<td>3.4</td>
<td>1.6</td>
<td>134.0</td>
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<td>31</td>
<td>30 July -5 Aug</td>
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<td>23.2</td>
<td>89.4</td>
<td>80.3</td>
<td>4.0</td>
<td>1.0</td>
<td>63.6</td>
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<tr>
<td>32</td>
<td>6 Aug-12 Aug</td>
<td>28.8</td>
<td>23.2</td>
<td>88.3</td>
<td>76.0</td>
<td>3.7</td>
<td>1.1</td>
<td>85.2</td>
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<tr>
<td>33</td>
<td>13 Aug-19 Aug</td>
<td>29.2</td>
<td>23.3</td>
<td>88.3</td>
<td>75.3</td>
<td>4.8</td>
<td>2.9</td>
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<td>34</td>
<td>20 Aug-26 Aug</td>
<td>30.2</td>
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<td>5.7</td>
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<td>35</td>
<td>27 Aug-2 Sep</td>
<td>30.0</td>
<td>22.7</td>
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<td>38</td>
<td>17 Sep - 23 Sep</td>
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<td>22.8</td>
<td>81.9</td>
<td>58.7</td>
<td>3.5</td>
<td>6.4</td>
<td>17.2</td>
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<td>39</td>
<td>24 Sep—30 Sep</td>
<td>27.1</td>
<td>21.4</td>
<td>90.6</td>
<td>84.4</td>
<td>5.3</td>
<td>1.1</td>
<td>95.6</td>
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<tr>
<td>40</td>
<td>1 Oct – 7 Oct</td>
<td>30.7</td>
<td>21.9</td>
<td>86.3</td>
<td>60.7</td>
<td>3.4</td>
<td>6.0</td>
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<td>41</td>
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<td>21.4</td>
<td>85.2</td>
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<td>6.7</td>
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<td>70.6</td>
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<td>15 Oct-21 Oct</td>
<td>33.0</td>
<td>18.5</td>
<td>82.6</td>
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<td>1.8</td>
<td>8.5</td>
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<tr>
<td>43</td>
<td>22 Oct- 28 Oct</td>
<td>30.5</td>
<td>14.9</td>
<td>79.7</td>
<td>31.1</td>
<td>2.9</td>
<td>9.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

*Observation started 7 days after inoculation and at weekly intervals

Table 2: Multiple regression analysis of Independent variable (abiotic factor) and dependent (PD) variable (2015)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Independent Variables</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Partial 'b' Value</td>
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<tr>
<td>1</td>
<td>Max. tem.</td>
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<td>2</td>
<td>Min. tem.</td>
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<td>3</td>
<td>Max RH</td>
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<td>4</td>
<td>Min RH</td>
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<td>5</td>
<td>Wind velocity</td>
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<td>7</td>
<td>Rain</td>
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<tr>
<td>8</td>
<td>evaporation</td>
<td>7.538982</td>
</tr>
</tbody>
</table>

Intercept a = 1508.78 Multiple R= 0.90 R²= 0.81 F value= 5.65

Table 3: Progression of Alternaria blight on Niger in relation to weather parameters with different date of sowing during kharif 2015

<table>
<thead>
<tr>
<th>Standard week, 2013</th>
<th>Meteorological weeks</th>
<th>Temperature (°C)</th>
<th>Relative Humidity (%)</th>
<th>Wind Velocity (km/hrs)</th>
<th>Sunshine (hrs)</th>
<th>Rain (mm)</th>
<th>Evaporation (mm)</th>
<th>AUDPC*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Max.</td>
<td>Min.</td>
<td>Max.</td>
<td>Min.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>18 Jun- 24 Jun</td>
<td>35.3</td>
<td>24.4</td>
<td>80.0</td>
<td>50.3</td>
<td>4.7</td>
<td>6.4</td>
<td>26.0</td>
</tr>
<tr>
<td>26</td>
<td>25 Jun-1Jul</td>
<td>32.6</td>
<td>25.0</td>
<td>5.0</td>
<td>51.7</td>
<td>8.0</td>
<td>6.2</td>
<td>2.7</td>
</tr>
<tr>
<td>27</td>
<td>2 July - 8 July</td>
<td>32.9</td>
<td>25.7</td>
<td>72.4</td>
<td>51.1</td>
<td>11.1</td>
<td>6.0</td>
<td>0.0</td>
</tr>
<tr>
<td>28</td>
<td>9 July- 15 July</td>
<td>34.7</td>
<td>26.2</td>
<td>69.7</td>
<td>44.5</td>
<td>14.3</td>
<td>5.0</td>
<td>0.0</td>
</tr>
<tr>
<td>29</td>
<td>16 July- 22 July</td>
<td>32.7</td>
<td>24.9</td>
<td>79.3</td>
<td>61.1</td>
<td>6.6</td>
<td>2.4</td>
<td>45.2</td>
</tr>
<tr>
<td>30</td>
<td>23 July- 29 July</td>
<td>27.8</td>
<td>23.0</td>
<td>92.1</td>
<td>88.1</td>
<td>7.0</td>
<td>2.4</td>
<td>292.2</td>
</tr>
<tr>
<td>31</td>
<td>30 July -5Aug</td>
<td>28.5</td>
<td>23.3</td>
<td>80.3</td>
<td>69.7</td>
<td>7.6</td>
<td>2.4</td>
<td>153</td>
</tr>
<tr>
<td>32</td>
<td>6 Aug-12 Aug</td>
<td>28.0</td>
<td>23.4</td>
<td>84.0</td>
<td>68.6</td>
<td>4.3</td>
<td>4.0</td>
<td>43.4</td>
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<tr>
<td>33</td>
<td>13 Aug-19 Aug</td>
<td>29.8</td>
<td>23.6</td>
<td>89.1</td>
<td>73.9</td>
<td>3.1</td>
<td>2.0</td>
<td>62.0</td>
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<tr>
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<td>20 Aug-26 Aug</td>
<td>30.3</td>
<td>23.8</td>
<td>79.4</td>
<td>61.3</td>
<td>6.0</td>
<td>6.5</td>
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</tr>
<tr>
<td>35</td>
<td>27 Aug-2 Sep</td>
<td>31.6</td>
<td>22.8</td>
<td>82.9</td>
<td>57.0</td>
<td>3.8</td>
<td>7.7</td>
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<tr>
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<td>3 Sep-9 Sep</td>
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<td>20.6</td>
<td>76.3</td>
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<tr>
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<td>10 Sep-16 Sep</td>
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<td>22.5</td>
<td>70.1</td>
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<td>7.7</td>
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<tr>
<td>38</td>
<td>17 Sep-23 Sep</td>
<td>30.3</td>
<td>23.5</td>
<td>86.1</td>
<td>72.1</td>
<td>5.7</td>
<td>3.2</td>
<td>41.6</td>
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<tr>
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<td>24 sep–30sep</td>
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<td>19.3</td>
<td>77.6</td>
<td>41.3</td>
<td>3.1</td>
<td>8.9</td>
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<tr>
<td>40</td>
<td>30 Sep–30 Sep</td>
<td>35.4</td>
<td>17.7</td>
<td>62.6</td>
<td>24.0</td>
<td>1.9</td>
<td>8.3</td>
<td>0.0</td>
</tr>
<tr>
<td>41</td>
<td>1 Oct–7 Oct</td>
<td>35.1</td>
<td>17.4</td>
<td>64.7</td>
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<td>9.1</td>
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</tr>
<tr>
<td>42</td>
<td>8 Oct-14 Oct</td>
<td>35.9</td>
<td>18.9</td>
<td>63.0</td>
<td>24.3</td>
<td>1.3</td>
<td>7.9</td>
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</tr>
<tr>
<td>43</td>
<td>15 Oct-21 Oct</td>
<td>34.3</td>
<td>16.6</td>
<td>64.7</td>
<td>24.7</td>
<td>1.5</td>
<td>8.1</td>
<td>0.0</td>
</tr>
</tbody>
</table>

(*Observation started 7 days after inoculation and at weekly intervals

Results of year 2013 and 2015 reveal similar trends in both the years in all the dates of sowings. In the starting week disease increased slowly in month of July when crop was young after getting uniform temperature range of 29-32°C and accidental rains it increased by faster rate and maximum AUDPC 147 to 289 and 180.87 to 290 was noted on 32nd to 34th week i.e in the month of August in 2013 and 2015 respectively. When crop at 40 to 60 days of age, temperature range from 29- 32°C, more than 70% relative humidity, more wind velocity and accidental rains which further helps in the progress of disease then in the 35th to 39th week disease remained more or less staple with slight up and down then from 41th to 43rd week AUDPC got disease declined. Our findings are in accordance with the results of Amaresh (2000)


These observations are useful for timely application of fungicide for checking further spread of the disease. This seems to be crucial stage when prophylactic spray of fungicides may be done to suppress the disease.

References

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