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Short Communication

Effect of climate variation on apple scab occurrence in Himachal Pradesh

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Apple (*Malus x domestica* Borkh.) is the most important fruit of temperate regions of the world. Rana *et al* (2011) reported that due to climate change the productivity of apple in Himachal Pradesh has decreased. Leaf wetness and high humidity coupled with moderate temperature favours disease development (Durga Prasad *et al* 2014). The present investigation was carried out to ascertain the role of rainfall, number of rainy days and temperature in apple scab occurrence in Himachal Pradesh.

The disease development was studied at hot spots of scab occurrence under field conditions for last twenty three years (1993 – 2013) at Kullu and two years (2014-2015) at Sharbo, Kinnaur districts of Himachal Pradesh. Data on total monthly rainfall (mm), number of rainy days (RD) coupled with average monthly temperature (^{0}C) were obtained from HRS- Seobagh (Kullu) Meteorology Laboratory and Regional Horticultural Research and Training Station, Sharbo, Kinnaur for 1993-2013 and 2014-2015 respectively. Data on disease incidence was calculated as per McKinney (1923).

Due to high rainfall (>225mm) and rainy days (>30 day) coupled with favourable temperature (15-25 ^{0}C) during primary and secondary infection led highest incidence of scab in 1995 and 1996. Less rainfall (198.7mm) with 22 rainy days (RD) during primary infection (March-May) of scab in 2000 exhibited zero infection in the district. During 2001, scab reappeared in the apple orchards of district Mandi whereas, traces of disease incidence was noticed only in Barsiani area of district Kullu which may be attributed to the prevalence of highly congenial weather conditions (255.9mm in 23 RD during ascospore emission period). Manifestation of favourable climatic conditions (163.5 & 223mm in 15 & 20 RD) during primary and secondary infection in 2004 exhibited scab in traces. It has also been indicated that scab leaves which defoliate early (before mid of September) do not contribute to the formation of pseudothecia, Thus it has also helped lowering the incidence of scab disease (Sharma, 2003a). During 2007 and 2008 less rainfall (5.2 mm 1RD Mar, 7.2 mm 2 RD Apr in order) in March and April did not allow the disease to flare up. During the

Table 1: Mean weather parameters and scab occurrence at Kullu, H.P. (1993-2013)

	Rainfall	SD (±)	Rainy day	SD (±)	Temperature	SD (±)	Scab	SD (±)
January	77.0	61.6	6.3	4.0	7.3	2.2	0.0	0.0
February	112.3	79.1	8.8	5.2	9.0	2.9	0.0	0.0
March	105.8	72.8	7.5	4.4	12.3	3.5	0.0	0.0
April	72.7	54.3	7.4	3.7	16.4	2.4	2.0	2.1
May	63.3	44.5	7.7	2.6	19.6	2.0	7.4	6.1
June	64.8	47.3	7.7	2.9	22.8	1.8	16.8	13.8
July	111.3	81.0	10.2	3.8	24.3	1.9	26.5	21.3
August	117.7	69.6	10.3	3.6	23.9	1.7	32.4	29.0
September	71.3	57.0	6.5	2.8	21.6	1.7	22.6	24.8
October	22.8	47.0	1.7	1.6	17.0	2.0	9.2	10.1
November	16.8	21.2	2.0	1.8	12.8	1.5	0.1	0.5
December	30.9	28.1	2.8	2.9	9.1	1.9	0.0	0.0

Table 2: Simple and partial correlation coefficients between disease incidence and meteorological factors.

Correlation pairs	Simple correlation	Partial correlation
Rainfall	0.1477**	0.0475**
Rainy days	0.5190**	0.3080*
Temperature	-0.6304*	-0.5350

*Significant at 1 per cent level of significance

**Significant at 5 per cent level of significance

year 2011, disease appearance was sporadic in Kullu district with maximum incidence of 45 per cent in some areas. However it was low to moderate form during 2012-13.However, the status of scab in district Kinnaur is confined to Nichar and Kalpa block but not in Pooh block as it receives scanty rainfall. Occurrence of favourable weather parameters (85.5 and 215 mm rainfall in 8 and 10 RD) in April and May 2014 coupled with low temperature (10.8-15.4^{0}C) was prerequisite for manifestation of primary infection of scab at Kalpa village. It has also been reported that overwintering pseudothecia may be initiated at temperature below 0^{o}C but their density was maximum at temperature between 4 and 8 ^{0}C. Disease was moderate to severe during 2015 due to the occurrence of frequent rainfall (158.9 & 90.5 mm &35 & 25RD) during ascospore emission period and secondary infection. Moreover, orchard situated in narrow (gorge) low lying area receiving high rainfall, RH coupled with favourable temperature (7.17-21.36^{0}C) during primary and secondary infection period exhibited high incidence of scab in Sangla and Kalpa village during 2014 and 2015.

The pooled analysis of simple and partial correlation coefficients of disease incidence with rainfall and rainy days was positive and highly significant but negative and significant with temperature (Table 2). Regression analysis of disease incidence with independent variables resulted in $R^2 = 0.487$.

$Y = 54.85 + 2.03(\text{Rainfall}) + 1.79(\text{RD}) + 3.57(\text{Temp})$

$R^2 = 0.487^*$

*Significance at 5 per cent level of significance

The present study leads to the inference that dominance of Rich-a Red and Royal Delicious coupled with frequent rains; more rainy days during primary and secondary infection with low temperature (20±1°C) favoured sporadic nature of apple scab in both Kullu and Kinnaur district. These results are in consonance with the finding of Mills (1944), Gupta and Lele (1980) and Sharma (2003).

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