



Effect of micrometeorological parameters on aphid and white rust epidemiology under different row direction in oilseed *Brassica*

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Received: 27 February 2017; Accepted: 27 June 2017

ABSTRACT

Globally rapeseed-mustard (*Brassica* spp.) is a major oilseed crop. India is the second largest cultivator of mustard followed by China. The oilseed production increased significantly after yellow revolution but increasing population made pressure on production. The major losses in mustard yield occurs due to the attack of different pest and diseases. An option to minimize the losses in production of oilseed *Brassica* can be the suppression of the pest and disease incidence through modification of microclimate by altering the crop row direction. This experiment was conducted to evaluate the impact of microclimate variability due to different crop row directions on pest and disease incidence. The pest and disease are highly sensitive to temperature and relative humidity (RH) within crop canopy environment. The two row direction treatment, i.e. North-South (N-S) and East-West (E-W) were studied at the experimental farm, ICAR-IARI, New Delhi during *rabi* season, 2013-14. Parameters like number of aphid per top 10 cm of main shoot, per cent disease index (PDI) of white rust, temperature and RH within crop canopy were recorded at regular interval. The result showed a significant higher value of mean profile temperature in N-S row direction as compared to E-W row direction and an opposite trend was found for RH. Aphid infestation and PDI for white rust infection in E-W direction were significantly higher by 36% and 11.44%, respectively over N-S direction. It was concluded that both aphid and white rust incidence were reduced in N-S direction due to microenvironment modification. Aphid population was found negatively correlated with mean profile temperature and positively correlated with RH..

Key words: Aphid, Relative humidity, Row direction, Temperature, White rust

India occupies a major position in the acreage and production of mustard in the world. The oilseed plays an important role in the economy of nation. Globally rapeseed-mustard (*Brassica* spp.) is a major oilseed crop. India is the second largest cultivator of mustard followed by China (Boomiraj *et al.* 2010). But unfortunately, the average productivity of mustard is low as compared to other mustard growing countries. The reduction in yield may be attributed to different biotic and abiotic stresses. The mustard crop is more vulnerable to a wide variety of insect pests from sowing till harvest than any other oilseed crops. Among the biotic stresses, aphid (*Lipaphis erysimi* Kalt) and white rust caused by *Albugo candida* (Pers.) Kuntze, are the most damaging pest and disease of rapeseed mustard in north-West India. These are generally responsible for significant yield reduction within short period of time. These harmful organisms reduce both the quality and quantity of seed yield.

Several studies showed that weather parameters play a vital role in the appearance, multiplication and disappearance of mustard aphids that affect the crop yield (Kumar *et al.* 2012). The maximum population of aphids accomplishes at the flowering period (January-February) for *B. juncea* and the incidence is largely governed by weather parameters like minimum temperature, maximum temperature and RH (Gami *et al.* 2002). Bakhetia and Sindhu (1983) calculated the mean yield loss due to aphid infestation is 54.2%, which varied from 35.4% to 73.3% in different varieties of mustard across different agro-ecological regions in India. Meena *et al.* (2013) concluded that sucking pest showed the negative correlation with temperature while positive correlation with relative humidity for many species, depending on their thermal requirements and host specificity. Meena *et al.* (2011) reported that about 60% reduction in yield of *Brassica juncea* is due to its high susceptibility to white rust.

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Seventeen races of *A. candida* have been reported from different cruciferous species around the world (Minchinton *et al.* 2005). Weather parameters like temperature, RH and rainfall are highly correlated with per cent disease index (PDI) of white rust (Bal *et al.* 2014). Weather parameters like maximum temperature, minimum temperature and

average RH favour the development of white rust disease if they varies from 26°C - 29°C, 14°C - 15°C and 60-70%, respectively (Sangeetha and Siddaramaiah 2007). Another study conducted by Bal and Kumar (2014) reported that there is a faster rate in development of white rust when the average temperature was between 11.4°C to 17.7°C and an average RH was more than 70%. The maximum disease severity was found in *B. juncea* at 110 days after sowing (Gupta *et al.* 2006).

We hypothesized that through changing crop row direction we can alter microenvironment, thereby, increase resource use efficiency and suppress pest and disease to some extent without the use of chemical pesticides. Therefore, the aim of this experiment was to evaluate the impact of microclimate variability due to different crop row directions on pest and disease incidence. The incidence of these pest and diseases are dependent on biotic as well as abiotic factors. Therefore it is difficult to predict the onset, spread and development of these pest and diseases. Hence, a systematic study on pest and disease incidence with appropriate weather parameters was necessary to understand the relationship of the level of infestation with the micro meteorological conditions prevailing within the canopy. Though some attempts have been made to study the effects of weather on aphid in some parts of north India where mustard crop is widely grown but there were some lacuna in relating the effects of agronomic practices on crop growth and aphid infestation with respect to weather conditions prevailing within the canopy. Though many studies have reported the effect to various abiotic factors on the pest and disease attack, very few studies have reported the effect of varying crop row direction on pest and disease incidence. Keeping this background in view, the present experiment was conducted with the objective to quantify the effect of crop row direction on micrometeorological parameters *vis-à-vis* the pest and disease incidence in mustard.

MATERIALS AND METHODS

A field experiment for this research was conducted at research farm of ICAR-IARI, New Delhi (28°64' N, 77°15' E, 229 m above mean sea level) during *rabi* season, 2013-14 with three mustard cultivars, viz. Pusa Vijay (P. Vijay), Pusa Mustard-21 (PM-21) and Pusa Bold (P. Bold). The experiment was laid out in 5 m² plot in split plot design with three replications. The different mustard cultivars were sown on 30th Oct, 2013 in two row directions, viz. north-south (N-S) and east-west (E-W). Sowing was done with hand drill, maintaining a row-to-row spacing of 45 cm and plant-to-plant spacing of 10 cm in two row directions. The soil of the experimental site was sandy loam to loam in texture and belonged to Holambi Series, which is a member of non-acidic mixed hyper-thermic family of Typic Ustocrepts, with medium to weak angular blocky structure. Main plot treatment was row directions, whereas sub plot treatment was cultivars. Relative humidity (RH) and air temperature within crop canopy were measured with the help of a pocket weather tracker at different crop heights

(0 cm, 30 cm, 60 cm, 90 cm, 120 cm and top of canopy) at around 14:00 hours (i.e., time of occurrence of daily maximum temperature). Mean of these parameters were calculated. Number of mustard aphid were counted from flowering to maturity at weekly intervals from top 10 cm portion of the central shoot of six randomly selected and tagged plants. Among six randomly selected plants, two were selected at northern side, next two plants were selected from middle and last two plants were selected from the southern side of the plot leaving the border rows. The average population of aphids were counted per plant for each plot. The incidence of white rust was recorded after abundant rainfall which was favourable weather element for its initiation. Ten plants were randomly selected and tagged for examining the disease severity on a disease scale (0-9) as per Couture (1980) at regular interval. The Per cent Disease Index (PDI) was calculated using the formula (Wheeler 1969).

$$\text{PDI} = \frac{\text{Sum of individual rating}}{\text{Number of leaves examined} \times \text{Maximum disease grade}} \times 100$$

The data sets were prepared for examination of variance as applicable to split plot design, to test differences among the treatments and their interactions using Statistical Analysis System (SAS, 2006). The separation of the treatment means of main plot and sub plot treatments was tested using least significance difference at 5% probability level with the help of Strengthening Statistical Computing for NARS (SSCNARS) - IASRI, New Delhi (<http://www.iasri.res.in/sscnars/>).

RESULTS AND DISCUSSION

Weather data during *rabi* 2013-14 was collected from the ICAR-IARI meteorological observatory at regular schedule and expressed in terms of standard meteorological weeks (SMW). Weekly mean maximum temperature varied between 17.7°C - 32.2°C but there was a sudden drop in 51st SMW and it remained below 20°C upto 4th SMW. Next two weeks were comparatively warmer with 21.6 and 21.7°C. It crossed 20°C from 8th SMW and increased progressively. The similar trend was seen in weekly mean minimum temperature. It ranged between 4.3°C to 22.9°C. Interestingly, the weekly mean minimum temperature increased by 1.9°C at 51st SMW over the previous week whereas, weekly mean maximum temperature did not show any change.

Weekly mean maximum RH varied less during this season. It was around 90% for the entire season but dropped to 82% in 13th SMW. Weekly mean minimum RH had a wide variation (38% to 81%) with clear peaks in 40th, 45th, 51st, 3rd, 7th, 9th SMW. About 256 mm of rainfall was received in 14 rainy days due to western disturbances. A significant amount of rainfall was received in 7th SMW and 9th SMW.

The mean profile temperature in E-W crop row direction was about 0.24°C lower than in N-S direction during the crop season whereas, the mean profile RH in E-W crop row direction was considerably higher (3.5%) than the N-S

Table 1 Mean profile temperature and relative humidity within mustard crop canopy grown in E-W and N-S directions

SMW	Temperature (°C)			Relative humidity (%)		
	E-W	N-S	ΔT	E-W	N-S	ΔRH
51	19.7	20.0	0.3	51.4	48.0	3.4
52	19.1	19.3	0.2	68.2	65.6	2.6
1	17.2	17.3	0.1	81.3	77.0	4.3
2	18.4	18.7	0.3	57.2	52.0	5.2
3	17.9	18.3	0.4	66.8	64.0	2.8
4	18.1	18.4	0.3	56.2	52.0	4.2
5	21.2	21.4	0.2	71.9	67.9	4.0
6	19.3	19.6	0.3	61.2	56.9	4.3
7	22.6	22.8	0.2	55.8	52.0	3.8
8	21.7	21.8	0.1	57.9	55.0	2.9
9	22.2	22.5	0.3	44.0	42.8	1.2
10	22.6	22.8	0.2	50.2	46.3	3.5
Average			0.24			3.5

oriented crop (Table 1). Crop sown in E-W row direction experiences less warm and more humid weather conditions during crop season than that of N-S oriented crop due to higher penetration of solar radiation in the space between the rows for N-S direction during the bright sunshine hours. The amount of intercepted photosynthetic active radiation

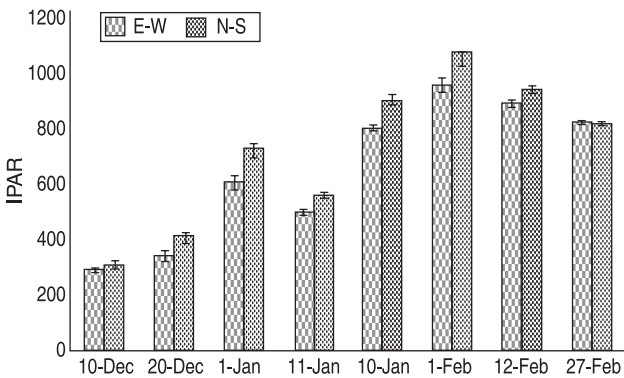


Fig 1 Variation in intercepted PAR affects by different row directions in mustard crop

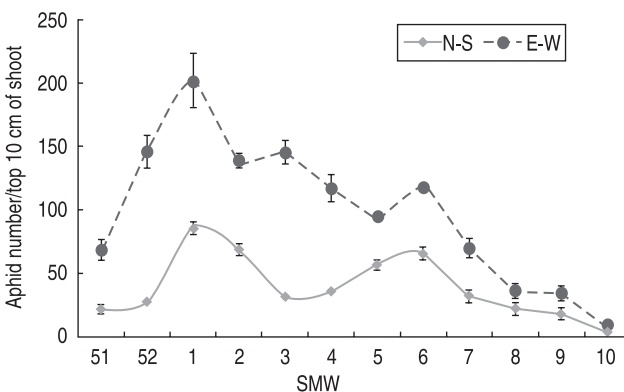


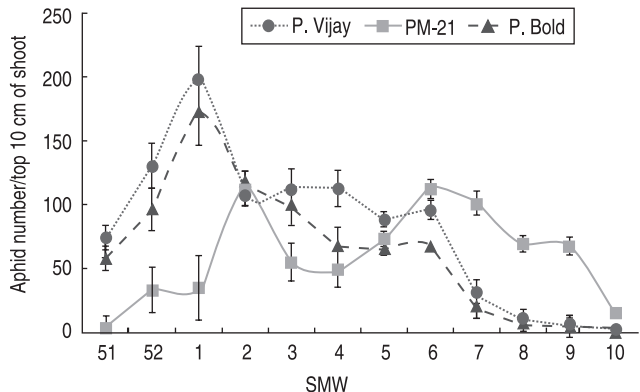
Fig 2 Effect of row directions and cultivars on aphid population in mustard crop

drives the temperature which was also significantly higher in N-S shown crop (Fig 1). Temperature and relative humidity within the crop canopy is generally different from the outside ambient temperature because diurnal variation of temperature within a canopy is less than that of outside. The heat use efficiency is significantly higher in N-S than that in E-W direction sown mustard crop (Goyal *et al.* 2015). The RH was found to be always higher within the canopy than that of outside, because of evaporation from the soil and transpiration from the leaves in the semi confined environment within the canopy. The temperature within the canopy determines the humidity, evaporation from the soil, transpiration from the lower level leaves and more importantly, insect pest and diseases. Kredl *et al.* (2012) also observed that the temperature was usually lower at the ground level in the wheat and rape stands. Net radiation and soil heat flux were found to be higher in irrigated cotton crop planted in N-S direction in Texas (Agam *et al.* 2012).

Aphid infestation

In order to assess the effect of row direction on aphid population, it was first mandatory to follow the pattern of aphid infestation during its life cycle. Aphid started appearing from 51st SMW onwards and reached a peak value during 1st SMW when the crop was at flowering stage (Fig 2). After that, it declined to some extent but maintained a good population during pod development stage. The appearance of aphid at 51st SMW may be attributed to sudden drop in weekly mean maximum temperature and increase in weekly mean minimum RH. Afterwards, peak aphid population was reached because crop was in flowering stage at this period. Thereafter, the aphid population decreased for some time due to migration of aphid to ventral side of the leaves for survival when minimum temperature was less than 5°C. Light rain in 52nd, 3rd and 4th SMWs and weekly minimum temperature (<20°C) made favourable situation for maintenance of their population.

Large variations were noticed across crop row direction and cultivars in aphid appearance and peak incidence (Fig 2). The aphid infestation was significantly higher in crop sown in E-W direction than that in N-S direction. The population reached a peak value of 203 and 86 aphids/10cm main shoot for E-W and N-S sown crop, respectively at 1st



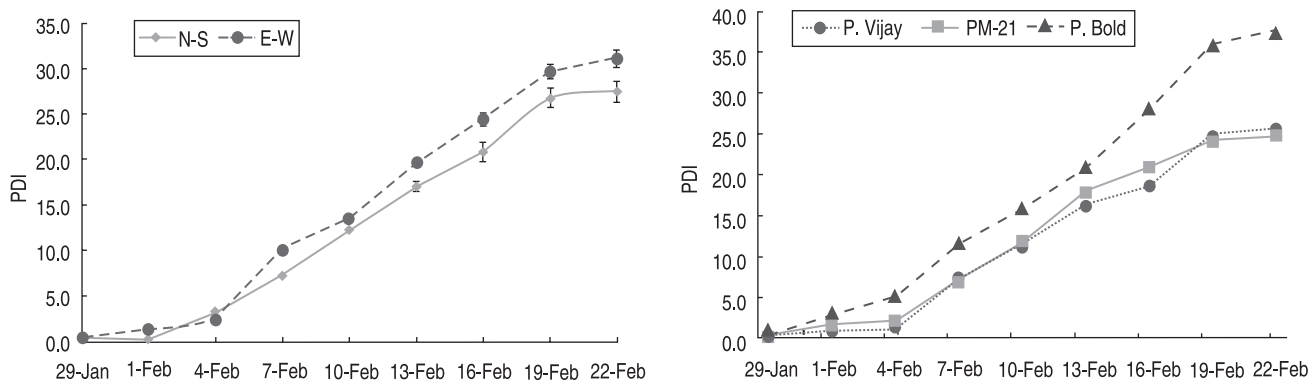


Fig 3 Effect of row directions and cultivars on PDI of white rust in mustard crop

SMW. The appearance of aphid in mustard depends on crop phenology and prevailing weather parameters within crop canopy (Narjary *et al.* 2013). The E-W crop row direction was more favourable to aphid infestation due to lower temperature and higher RH within crop canopy than that of N-S. The flowering stage of mustard has been reported to be the most vulnerable stage to *L. Erysimi* (Hasan and Singh 2010, Hussain *et al.* 2015, Sahito *et al.* 2016).

The aphid population was significantly different across the cultivars for entire crop season (Fig 3). The maximum number of aphids (199 aphids/10cm main shoot) was found in Pusa Vijay, followed by Pusa Bold (172 aphids/10cm main shoot) during 1st SMW but for Pusa Mustard 21, aphid population attained two peaks in 2nd and 6th SMW. The significantly higher aphid population was recorded from 51th to 3rd SMW in Pusa Vijay sown in E-W direction and from 6th to 10th SMW in Pusa Mustard 21 sown in the same (E-W) direction. The significantly lower aphid population was found in PM 21 in 52nd and 1st SMW and from 2nd to 10th SMW in P. Bold consistently. The delay in peak in PM-21 cultivar may be attributed to the delay in flowering and long flowering period by that cultivar.

White rust infection

Generally the PDI of white rust followed the growth curve. White rust disease appeared in crop around the last week of January 2014 when the crop was around 87 days old (Fig 3). After that the infection progressed rapidly and peak value of PDI was recorded on 22th February when the crop was 107 days old. According to the supportive study by Sangeetha and Siddaramaiah (2007), the disease development was initially slow and appeared at 11th week of the crop. Significantly higher value of PDI (31.0%) was recorded in E-W direction than that of N-S direction (27.5%). PDI values were significantly different for three cultivars also. The lowest (24.8%) and the highest (37.3%) PDI were recorded in PM-21 and P. Bold, respectively at the end of the season.

The infection of white rust starts from the lower leaves near the soil because spores survive in the soil and infect the lower most leaves in favourable weather. The variation in average temperature between 15°C to 20°C and occurrence

of rainfall were the main reason for appearance of white rust in 3rd SMW. The white rust infection was wiped out at the end of February due to starting of leaf senescence. The chances of white rust infection was reported to be high if temperature remained within the range of 10°C to 20°C for 150 hours, relative humidity remained above 80% for 180 hours and cumulative bright sunshine hours below 40 hours (Kumar and Chakravarty 2008).

The micro-environment of N-S became unfavourable for the aphids and white rust to some extent because intercepted PAR within the N-S oriented canopy was more than that of E-W oriented canopy and it altered the micro-environment of the canopy by increasing the temperature and reducing the relative humidity. Therefore, the crop sown in N-S direction was significantly less infected by both aphid and white rust than that sown in E-W direction. As far as the cultivars are concerned, inherent degree of susceptibility of the cultivars played their role.

Seed yield

The seed yield was significantly increased by 5% in crop sown in N-S direction than that in E-W direction. The PM 21 recorded the highest (1925 kg/ha) while P. Vijay (E-W) recorded the lowest (1681 kg/ha) seed yield. This may be due to the low infestation of pest and disease in the N-S oriented crop. Similar results were obtained by different workers in different crops (Bal and Kumar 2014, Goyal *et al.* 2015, Hussain *et al.* 2015, Sahito *et al.* 2016) at different locations.

Relationship of aphid infestation with mean profile temperature and relative humidity

The correlation of aphid infestation with mean profile temperature and RH (during the aphid infestation) of mustard within canopy for each row direction along with the pool data are presented in Fig 4. Aphid population was highly negatively correlated ($r=0.77$) with mean profile temperature (Fig 4a). On the other hand, mean profile RH showed a very strong positive correlation ($r = 0.75$) with aphid population (Fig 4b). The aphid infestation was better correlated with temperature and RH within crop canopy in case of E-W sown crop than the N-S oriented crop (Fig 4c, d, e and

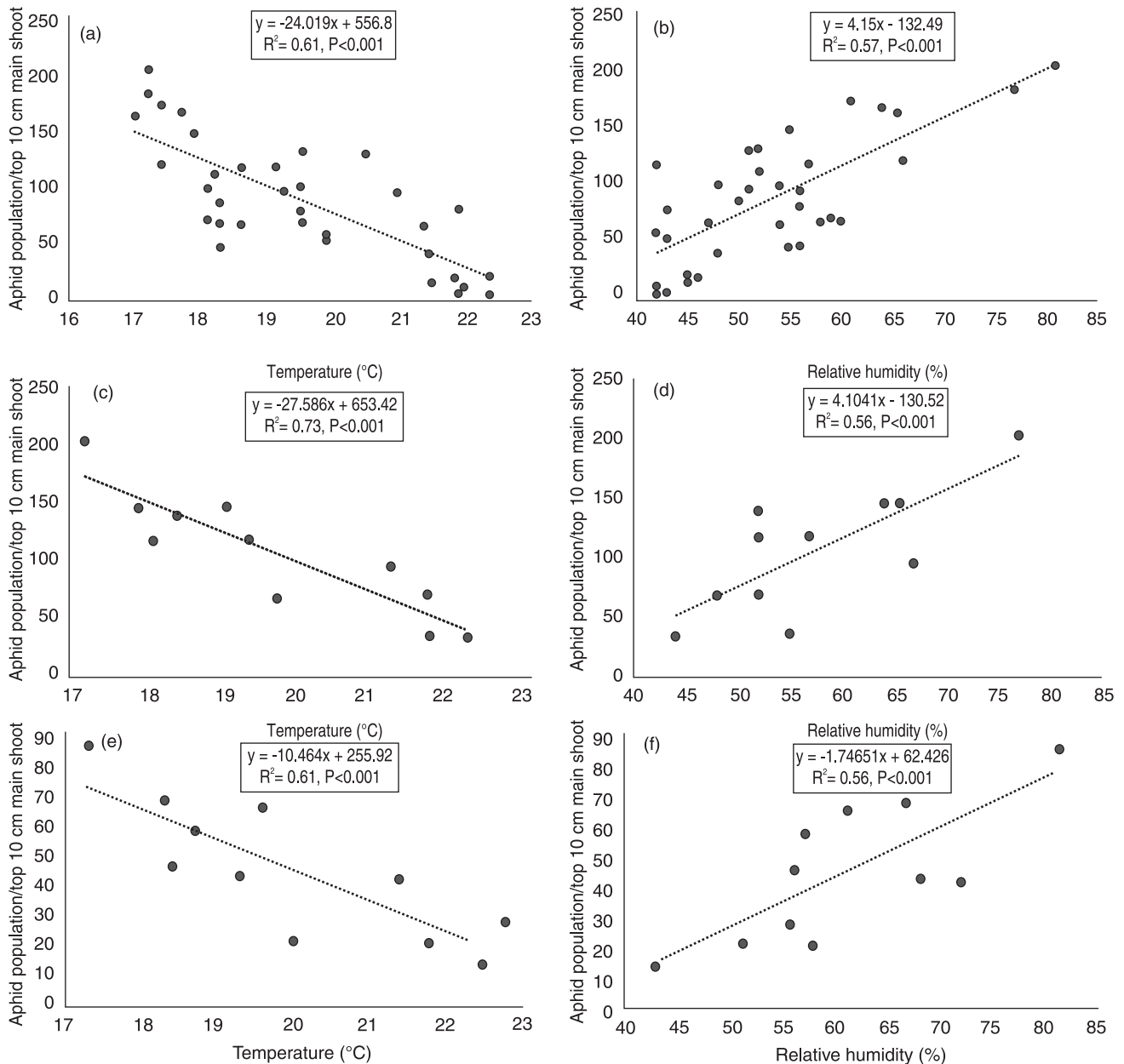


Fig 4 Relationship of aphid infestation with mean profile temperature and mean profile RH. (a,b) Pooled data, (c,d) E-W sown crop, and (e,f) N-S sown crop.

f). The results were in conformity with those reported by Hasan and Singh (2010) at Pantnagar; Meena *et al.* (2013) at Rajasthan but differs with a few (e.g. Aheer *et al.* 2007, Wains *et al.* 2010).

The study clearly showed that micrometeorology of crop canopy can be modified by changing the direction of sowing of mustard in North-West India. Lower temperature and higher humidity in E-W sown crop is more conducive for aphid and white rust infestation by negatively impacting the crop productivity.

Our preliminary result show that sowing in N-S direction may be beneficial for reduction the pest and disease incidence in the mustard crop. Therefore, it may be suggested to farmers to prefer N-S oriented sowing of mustard in North-West India to reduce the aphid infestation

and white rust infection to certain extent without use of chemical pesticides. Among all cultivars, Pusa mustard-21 may be recommended for the point of its genetic behaviour for low disease infection and aphid infestation. This may also reduce the pesticides application to some extent. Further, the functional relationship developed between micrometeorological parameters (temperature and RH) with aphid infestation, may be useful for incorporation in weather based pest and disease model/ decision support systems, which can be scaled to an early warning system.

REFERENCES

- Agam N, Kustas W P, Evett S R, Colaizzi P D, Cosh M H and McKee L G. 2012. Soil heat flux variability influenced by row direction in irrigated cotton. *Advances in Water Resources*

- 50: 31–40.
- Aheer G M, Munir M and Ali A. 2007. Impact of weather factors on population of wheat aphids at Mandi Bahaud-Din district. *Journal of Agricultural Research* **45**: 61–6.
- Bakhetia D R C and Sindhu S S. 1983. Effect of rainfall and temperature on the mustard aphid *Lipaphis erysimi* (Kaltenbach). *Indian Journal of Entomology* **45**: 202–5.
- Bal R S, Kumar A and Singh P. 2014. Epidemiology and management of white rust and Alternaria blight of Indian mustard. *Journal of Research, Punjab Agricultural University* **51**(2): 146–9.
- Bal R S and Kumar A. 2014. Studies on the epidemiology of white rust and Alternaria leaf blight and their effect on the yield of Indian mustard. *African Journal of Agricultural Research* **9**(2): 302–6.
- Boomiraj K, Chakrabarti B, Aggarwal P K, Choudhary R and Chander S. 2010. Assessing the vulnerability of Indian mustard to climate change. *Agriculture, Ecosystems and Environment* **138**(3–4): 265–73.
- Garni J M, Bapodra J G and Rathod R R. 2002. Population dynamics of mustard aphid [*Lipaphis erysimi* (Kaltenbach)] in relation to weather parameters. *Indian Journal of Plant Protection* **30**(2): 202–4.
- Goyal A, Das D K, Sehgal V K, Vashisth A, Mukharjee J, Pradhan S and Singh J. 2015. Relationship of thermal indices with biophysical parameters and seed yield of oilseed *Brassica* cultivars sown in two different row directions. *Journal of Agricultural Physics* **15**(1): 38–44.
- Gupta K, Prem D, Nashaat N I and Agnihotri A. 2006. Response of interspecific *Brassica juncea*/*Brassica rapa* hybrids and their advanced progenies to *Albugo candida* (white blister). *Plant Pathology* **55**: 679–89.
- Hasan W and Singh C P. 2010. Relationship between the population of mustard aphid, *Lipaphis erysimi* (Kaltenbach) and weather parameters on different cultivars of Indian mustard (*Brassica juncea* L.). *Journal of Plant Protection Sciences* **2**(1): 71–6.
- Hussain A, Razaq M, Zaka S M, Shahzad W and Mahmood K. 2015. Effect of aphid infestation on photosynthesis, growth and yield of *Brassica carinata* A. Braun. *Pakistan Journal of Zoology* **47**(5): 1335–40.
- Kredl Z, Streda T, Pokorny R, Kmoch M and Brotan J. 2012. Microclimate in the vertical profile of wheat, rape and maize canopies. *Acta universitatis agriculturae et silviculturae mendelianaebrenensis* **1**: 79–90.
- Kumar G and Chakravarty N V K. 2008. A simple weather based forewarning model for white rust in *Brassica*. *Journal of Agrometeorology* **10**(1): 75–80.
- Kumar V, Kumar A and Chattopadhyay C. 2012. Design and implementation of web-based aphid (*Lipaphis erysimi*) forecast system for oilseed *Brassic*as. *Indian Journal of Agricultural Sciences* **82**(7): 618–22.
- Meena P D, Awasthi R P, Godika S, Gupta J C, Kumar A, Sandhu P S, Sharma P, Rai P K, Singh Y P, Rath A S, Prasad R, Rai D and Kolte S J. 2011. Eco-friendly approaches managing major diseases of Indian mustard. *World Applied Sciences Journal* **12**(8): 1192–5.
- Meena R S, Ameta O P and Meena B L. 2013. Population dynamics of sucking pests and their correlation with weather parameters in chilli, *Capsicum annum* L. crop. *Bioscan* **8**(1): 177–80.
- Minchinton E, Petkowski J and Falloon R. 2005. White blister of vegetable *Brassic*as crop and food research. Department of Primary Industries, State Government of Victoria. Info sheet No. 3-21.
- Narjary B, Adak T, Meena M D and Chakravarty N V K. 2013. Population dynamics of mustard aphid in relation to humid thermal ratio and growing degree days. *Journal of Agricultural Physics* **13**(1): 39–47.
- Sahito H A, Solangi R, Kousar T, Shah Z H. and Mangrio W H. 2016. Population fluctuation of aphids, *Lipaphis erysimi* (Kalt) with response of biological control under mustard field conditions. *Journal of Entomology and Zoology Studies* **4**(5): 326–31.
- Sangeetha C G and Siddaramaiah A L. 2007. Epidemiological studies of white rust, downy mildew and *Alternaria* blight of Indian mustard (*Brassica juncea* (Linn.) Czern. And Coss.). *African Journal of Agricultural Research* **2**(7): 305–8.
- Wains M S, Ali M A, Hussain M, Anwar J, Zulkiffal M and Sabir W. 2010. Aphid dynamics in relation to meteorological factors and various management practices in bread wheat. *Journal of Plant Protection Research* **50**: 385–92.
- Wheeler B E J. 1969. *An Introduction to Plant Diseases*, p 301. John Wiley and Sons Limited, London.