



Full Length Article

Spatio-temporal Patterns of Mungbean Yellow Mosaic Virus and White Fly Population in Relation to Epidemiological Factors

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Abstract

The present study was designed to investigate spatio-temporal pattern of mungbean yellow mosaic virus [MYMV] and its vector in relation to epidemiological conditions *i.e.*, minimum and maximum temperature, rainfall, wind speed and relative humidity on four commercially grown mungbean [*Vigna radiate* (L.) Wilczek] varieties namely M-6, NM-51, NM-92 and AZRI-06. The study was conducted in experimental area of the Department of Plant Pathology, University of Agriculture Faisalabad under randomized complete block design during month of 15 June 2016. AZRI-06 was found the most effective for cultivation under prevailing environmental conditions. Spatial and temporal pattern of MYMV and its vector demonstrated that all environmental variables were significantly correlated with whitefly population and disease severity. MYMV disease severity was recorded maximum at minimum and maximum temperature 17 and 29.9°C, respectively relative humidity 67%, rainfall 5.5 mm and wind speed 1 km/h. Similarly, whitefly population was recorded maximum at minimum temperature 15°C, maximum temperature 29°C, relative humidity 69% and rainfall and wind speed 5.1 mm and 4.8 km/h. It was concluded that with progress in distance and time, temperature (minimum and maximum), wind speed, rainfall and relative humidity, the MYMV disease incidence and its vector populations also increased. © 2018 Friends Science Publishers

Keywords: *Bemisia tabaci*; Correlation; Epidemiological factors; Mungbean; Whitefly population

Introduction

Mungbean is severely attacked by mungbean yellow mosaic virus (MYMV) that belongs to genus *Begomovirus* and family *Geminiviridae* (Paul *et al.*, 2013). Pathogen has genome size 2.5 to 3.0 kb (Fauquat, 1994) and caused huge yield losses every year (Habib *et al.*, 2007). The virus was first identified in severe epidemic form in 1955 from the farmer's fields of India at seedling stage and losses were recorded 70-100% (Usharani *et al.*, 2004). The viral pathogen severely damages the crop by yellowing of leaves, deforming of the flowers and pods that ultimately lead to total yield loss (Akhtar *et al.*, 2009). The main symptoms of this disease include stunted growth with no or rare production of flowers and pods that contain small shriveled seeds. The infected pods twisted upwards and showed late ripening due to this yield losses may reached up to 90% (Honda and Ikegami, 1986). Management of MYMV mainly depends upon reducing the number of white fly populations by application of pesticides but this technique is not effective under severe vector attack (Oliveira, 2001).

MYMV causes 300 million US\$ losses every year in various leguminous crops (Rashid *et al.*, 2004). Yield losses may vary from 5 to 100% due to number of whitefly populations, vulnerable variety and disease severity percentage (Rathi, 2002). The adult white fly acquires and

transmits the virus to infect host plant within fifteen minutes. The latent period is less than four hours (Nariani, 1971). The female adults can hold infection for ten days whereas male adults hold it only for three days. Both male and female adults cannot retain infectivity throughout their life span. Female adults are three times more effective vector as compared to the male adults (Rathi, 2002). The pathogen do not transferred to the next generation through eggs (Ahmad and Harwood, 1973). Therefore, this is the need of the hour to evaluate mungbean varieties for identification of new resistant sources against MYMV (Chandrashekar and Shashank, 2017).

Epidemiological studies help in disease prediction and threats of severe disease epidemics, and the incidence of economic yield losses. Several decision support systems and disease forecasting models have been developed and being used in the successful management of various diseases of economic crops. Epidemiological factors are significant variables of disease outbreaks, as climate effects disease progress and plays significant role in disease spread (Khan *et al.*, 2012). Hence a comprehensive investigation of epidemiological variables is required for developing a consistent disease predictive model. High precipitation during month of August was crucial for the disease progress (Livinder *et al.*, 2009).

Keeping in view all above mentioned facts the main goal of current investigation was to determine the spatial and temporal pattern of MYMV disease incidence and *Bamesia tabaci* in relation to epidemiological factors.

Materials and Methods

Experimental Material

Four lines of mungbean were collected from the Institute of Pulses, Ayyub Agriculture Research Institute-Faisalabad, Pakistan. The research was conducted in experimental area of Department of Plant Pathology, University of Agriculture Faisalabad during summer season 2016. The evaluation of mungbean genotypes was done against MYMV under field conditions. Each line was planted in a row (3 m length with 30 cm inter row distance) following randomized complete block design (RCBD). Nursery was not inoculated with chemicals to enhance maximum chances of early attack of MYMV disease infection and *B. tabaci*. To maintain nursery in good conditions, all recommended agronomic practices were also followed.

Data recording: To observe spatial and temporal pattern, after appearance of mungbean yellow mosaic virus (MYMV) disease symptoms, data was recorded on all the four genotypes. Data for disease severity was recorded following 0-5 rating scale as described by Bashir *et al.* (2005). Disease incidence and white fly population were recorded using method given by Ashfaq *et al.* (2008).

$$\text{Disease incidence} = \frac{\text{No. of infected plants}}{\text{Total number of plants}} \times 100$$

Relationship of environmental factors with MYMV: Epidemiological data consists of minimum and maximum temperatures, wind speed, relative humidity and rainfall was collected from a meteorological station of University of Agriculture, Faisalabad (www.uaf.edu.pk).

Statistical Analysis

Statistical analysis was performed through statistical tests by using SAS/ STAT statistical software (SAS, 1990). Data for disease incidence, whitefly populations and environmental parameters were analyzed through correlation and regression analysis to estimate the relationship with environmental factors and disease progress. Epidemiological factors having statistically significant impact on disease development were graphically plotted.

Results

Evaluation of mungbean genotypes under field conditions exhibited that variety AZRI-06 was found resistant (R), NM-92 moderately resistant (MR), NM-51 moderately susceptible (MS) and M-6 demonstrated highly susceptible (HS) response against mungbean yellow mosaic virus (Table 1).

Table 1: Results of Screening of different mungbean varieties against MYMV

S/N	Varieties	% Infection	Response
1	AZRI-06	4.167a	Resistant
2	NM-92	9.767b	Moderately resistant
3	NM-51	19.200c	Moderately susceptible
4	M-6	45.21abc	susceptible

LSD = (1.4856)

Table 2: Correlation of environmental conditions with MYMV disease incidence and whitefly population

Environmental Variables	V-AZRI-06	V-NM-51	V-M-6	V-NM-92	Whitefly Population
Maximum Temperature (°C)	0.59	0.45	0.5	0.35	0.74*
Minimum Temperature (°C)	0.22	0.37	0.32	0.5	0.04
Temperature (°C)	0.79	0.85*	0.72	0.87*	0.98**
Rainfall (mm)	0.06	0.03	0.07	0.03	0.01
Relative Humidity (%)	0.97**	0.92**	0.9**	0.86*	0.76
Wind speed (km/h)	0.01	0.01	0.01	0.02	0.07
Whitefly Population	0.85*	0.96**	0.93**	0.95**	0.72
Temperature (°C)	0.03	0.01	0.01	0.01	0.07
Wind speed (km/h)	-0.86*	-0.93**	-0.89*	-0.9**	0.89*
Whitefly Population	0.02	0.01	0.02	0.01	0.04

Upper values indicated Pearson's correlation coefficient Lower values indicated level of significance at 5% probability *= significant ($P < 0.05$); **= highly significant ($P < 0.01$)

Relationship of epidemiological conditions with MYMV disease incidence and white fly populations: Correlation of epidemiological variables with mungbean yellow mosaic virus MYMV disease incidence and white fly populations were observed at variety level. All environmental variables *i.e.*, minimum and maximum temperatures, relative humidity and rainfall demonstrated statistically significant correlation with MYMV disease incidence on all four genotypes except wind speed that showed negative correlation to MYMV disease incidence on all the four genotypes. A significant positive relationship was observed between whitefly populations and all epidemiological variables that showed there is increasing trend in white fly population with increase in all environmental conditions (Table 2).

Characterization of epidemiological factors conducive for MYMV disease progress and white fly population: All genotypes viz. V1 = AZRI-06, V2 = NM-92, V3 = NM-51, V4 = M-6 were subjected to regression analysis to characterize the critical ranges of epidemiological conditions effective for urdbean yellow mosaic virus disease development. Results demonstrate that maximum disease severity was recorded on V4-M-6 at maximum and minimum temperature 29.9°C and 17°C, relative humidity 67%, rain fall 5.5 mm and wind speed 1 km/h; while all other three varieties showed less disease severity at same environmental conditions as illustrated in Fig. 1, 2, 3, 4 and 5. Similarly, whitefly population was observed maximum at maximum temperature 29°C, minimum temperature 15°C, relative humidity 69%, rainfall 5.1 mm and wind speed 4.8 km/h (Fig. 6, 7, 8, 9 and 10).

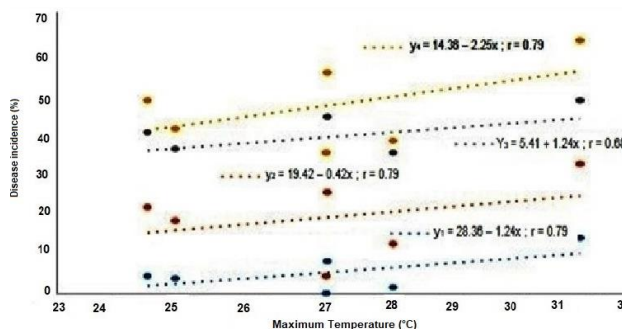


Fig. 1: Relationship of maximum temperature with MYMV disease incidence recorded on four mungbean varieties (Y1=AZRI-06, Y2= NM-92, Y3= NM-51, Y4=M-6) during 2016

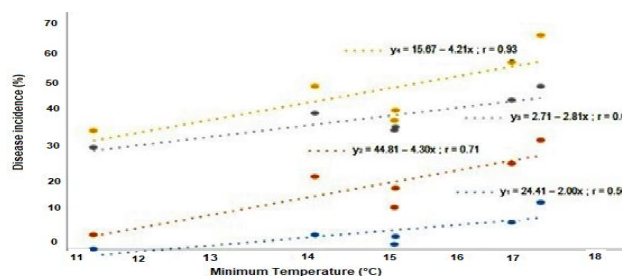


Fig. 2: Relationship of minimum temperature with MYMV disease incidence recorded on four mungbean varieties (Y1=AZRI-06, Y2= NM-92, Y3= NM-51, Y4=M-6) during 2016

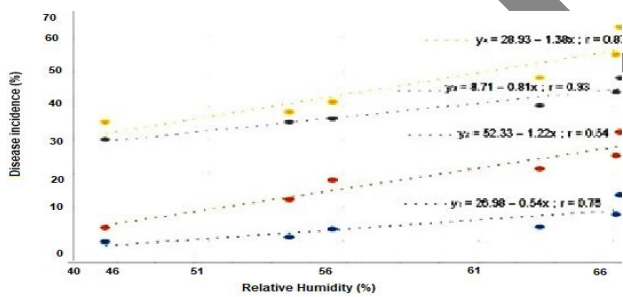


Fig. 3: Relationship of relative humidity with MYMV disease incidence recorded on four mungbean varieties (Y1=AZRI-06, Y2= NM-92, Y3= NM-51, Y4=M-6) during 2016

Spatial pattern of disease incidence demonstrated that maximum disease severity was observed after 3 week intervals. Disease prevalence decreased by increasing distance in first week after that disease prevalence increased with increasing distance in that weeks. Maximum disease prevalence was noted at 15th day (Fig. 11) at maximum temperature 24.7°C (Fig. 12) minimum temperature 15°C (Fig. 13), relative humidity 66.1% (Fig. 14) and rainfall 0.9 mm (Fig. 15).

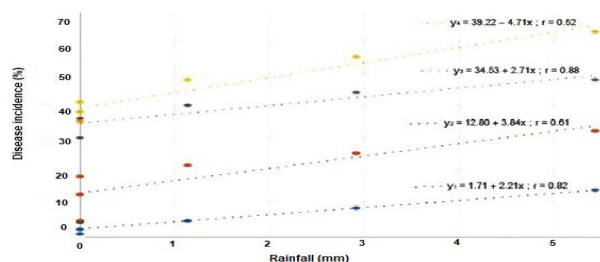


Fig. 4: Relationship of rainfall with MYMV disease incidence recorded on four mungbean varieties (Y1=AZRI-06, Y2= NM-92, Y3= NM-51, Y4=M-6) during 2016

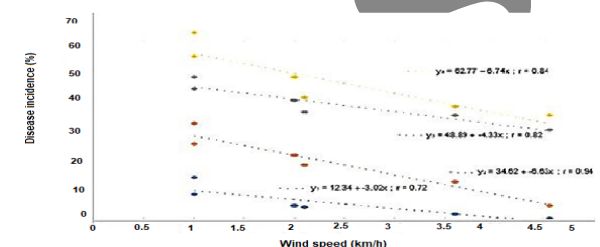


Fig. 5: Relationship of windspeed with MYMV disease incidence recorded on four mungbean varieties (Y1=AZRI-06, Y2= NM-92, Y3= NM-51, Y4=M-6) during 2016

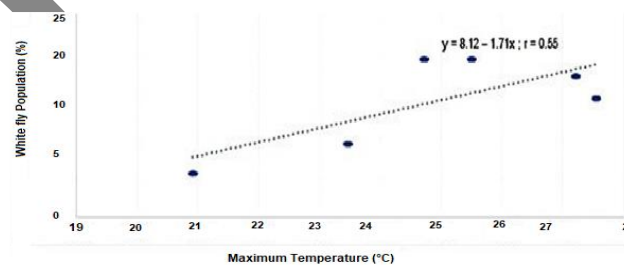


Fig. 6: Relationship of maximum temperature with whitefly population

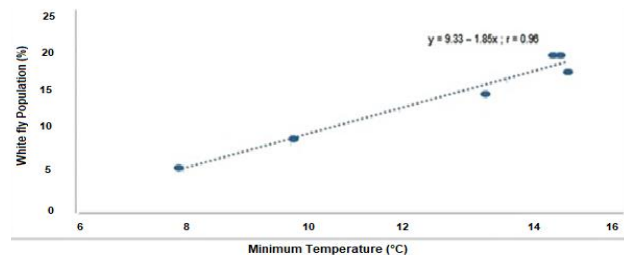


Fig. 7: Relationship of minimum temperature with Whitefly population

Discussion

Evaluation of mungbean genotypes exhibited that among all four varieties AZRI-06 was found the most effective against MYMV. The findings of current investigation were familiar

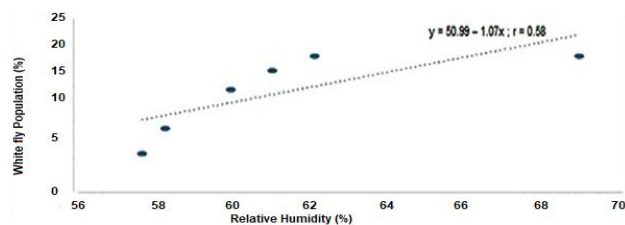


Fig. 8: Relationship of relative humidity with Whitefly population

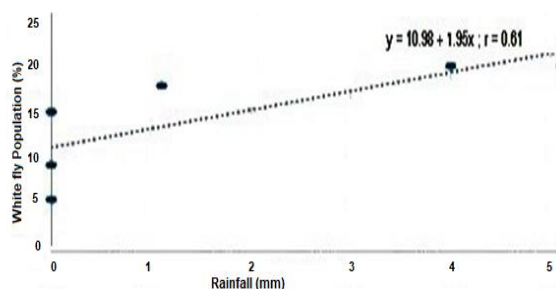


Fig. 9: Relationship of rainfall with whitefly population

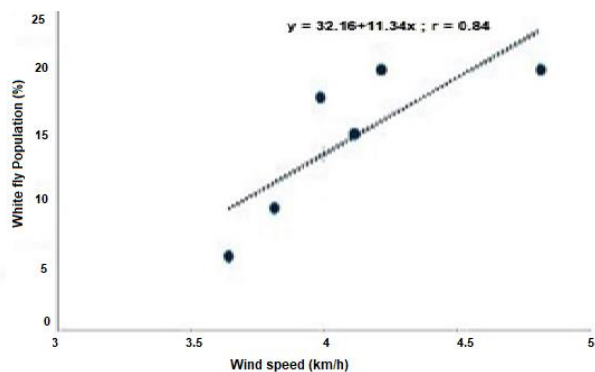


Fig. 10: Relationship of wind speed with Whitefly population

with the studies of Akhtar *et al.* (2009) who determined the resistance level of 146 mungbean genotypes against MYMV. Among these, only one genotype exhibited resistance against MYMV which indicated that this disease was a serious problem in all mungbean growing areas. Similarly, Shad *et al.* (2006) evaluated 254 genotypes; all genotypes exhibited moderately susceptible to highly susceptible response to this disease. For the identification of new resistance sources against mungbean yellow mosaic virus, continuous evaluation of germplasm during every crop season is necessary. There was severe disease outbreak in the third week of data scoring. Seedling stage is the most crucial stage for MYMV disease occurrence because vector was very active during that time period. This was because of high carrier populations and some other epidemiological variables as the temperatures (maximum and minimum) at this stage were favorable for carrier and virus multiplication.

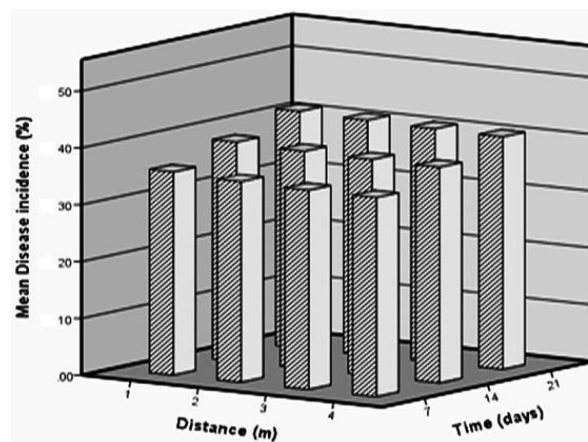


Fig. 11: Relationship between time, distance and MYMV disease incidence on mungbean varieties

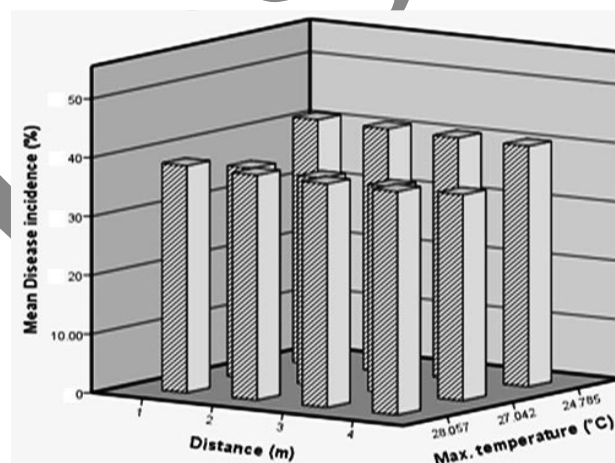


Fig. 12: Relationship between maximum temperature, distance and MYMV disease incidence on mungbean varieties

At seedling stage, temperature was most conducive because early arrivals of the virulent carrier *B. tabaci* that cause the early progress of mungbean yellow mosaic virus. Habib *et al.* (2007) also showed that crop is more sensitive to MYMV at early stage rather than maturity. Shah *et al.* (2006) indicated that chances of disease spread are decreased with increased of crop maturity.

Considering the characterization of epidemiological factors, all epidemiological conditions proved conducive for BYMV disease progress except wind speed (km/h) that exhibited statistically negative relationship with disease development. Maximum disease spread was recorded at 16.8 and 29.9°C minimum and maximum temperatures respectively. The findings of current investigation confirmed the study of Khan *et al.* (2012). Similarly, Livinder *et al.* (2009) stated that minimum and maximum temperatures ranging from 34-35 and 26-27°C,

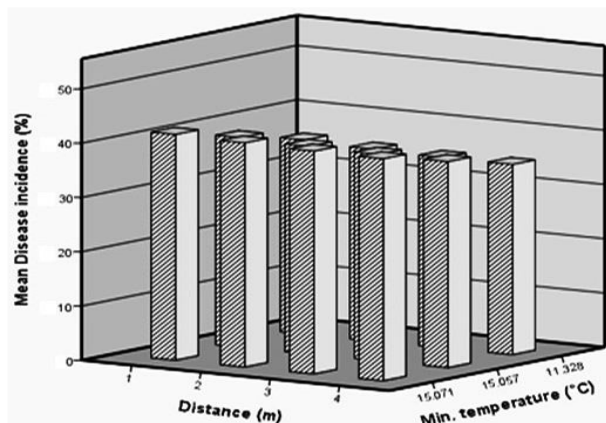


Fig. 13: Relationship between minimum temperature, distance and MYMV disease incidence on mungbean varieties

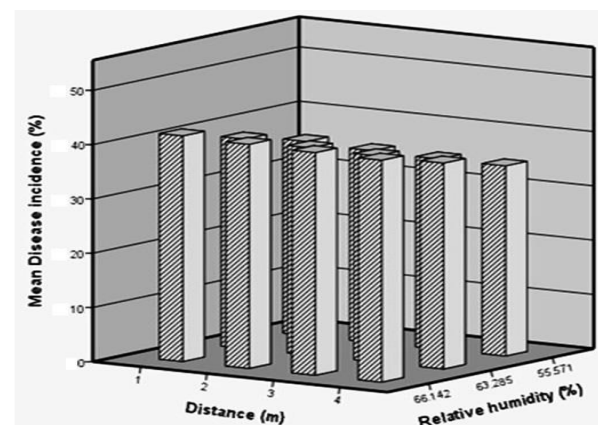


Fig. 14: Relationship between relative humidity, distance and MYMV disease incidence on mungbean varieties

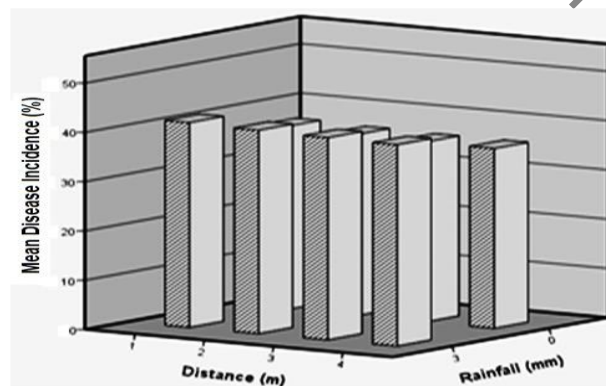


Fig. 15: Relationship between rainfall, distance and MYMV disease incidence on mungbean varieties

respectively are most conducive for the disease spread whereas, rain fall and relative humidity had significant correlation with the disease progress. Favorable minimum and maximum temperature ranges for mungbeab yellow

mosaic virus disease spread and the relationship of relative humidity and rainfall to mungbean yellow mosaic virus disease development were also studied by Srivastava and Prajapati (2012). Similarly, significantly positive correlation of temperature, rainfall and relative humidity with MYMV disease development was recorded by Khan *et al.* (2006). Environmental conditions of the world are varying continuously because of various epidemiological factors. Therefore, it is need of the hour to re-examine periodically the relationship between MYMV disease infection and environmental conditions. Spatio-temporal studies of viral diseases are helpful to evaluate the dynamics of disease development, consideration on the importance of primary inoculum and mechanisms involved in the vector spread (Perry, 1996). Perry (1995) studied that spatio-temporal investigation of MYMV disease might be useful to analyze the hypothesis on the dynamics of virus and disease spread and including those concerned with the significance of primary inoculum. A new technique regarding spatial analysis by distance guides (SADIE) was established to quantify spatial pattern of disease development.

Conclusion

It was concluded that except wind speed all environmental factors, shown significant correlation with MYMV disease incidence and whitefly population. Spatio-temporal patterns of MYMV and whitefly indicated that with increase in time and distance, the disease incidence and whitefly population increased.

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