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Relationship of whitefly population build up with the spread of yellow mosaic virus on soybean

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Abstract
Five soybean varieties, JS-335, JS-9305, KDSB-2042, KSL-441 and KSL-20 were screened against whitefly and yellow mosaic disease in the field. The highest and lowest prevalence of yellow mosaic virus (YMV) was recorded in JS-335 and JS-9305 respectively and incidence ranged from 5.83 to 45.00% during first year, 2011 and 7.50 to 44.17% during second year, 2012. There was a poor and insignificant quadratic polynomial relationship ($y = -0.173x^2 + 11.06x – 175.5$ & $R^2 = 0.285$) between temperature and whitefly population build up in soybean field. The relationship between relative humidity and whitefly population build up in the field was found significant but negatively correlated ($y = -0.019x^2 + 3.517x - 154.5$ & $R^2 = 0.678$). The increase of whitefly population in the field was positively correlated with the spread of YMV in the soybean field ($Y= 0.001x^2 - 0.055x + 1.498$ & $R^2 = 0.324$).

Keywords: Soybean, screened, prevalence, YMV, whitefly

1. Introduction
Soybean [*Glycine max* (L.) Merrill] is known as 'Golden bean' and miracle crop of 20th century. It is highly proteinaceous (40-43%) among legumes and also good source of oil (21-23%). Soybean faces several pathogenic assaults during growth period. Several fungal, bacterial, nematode and viral diseases attack soybean from sowing to harvesting stage. Among these yellow mosaic virus (YMV) is one of the most threatening virus manifesting typical yellow mosaic symptoms. Yellow mosaic in soybean has been reported to be caused by mungbean yellow mosaic virus (MYMV). Pierce [14] and Nariani [12] found that the yellow mosaic disease of soybean in India was caused by mungbean yellow mosaic virus. In central India it was reported in the form of mungbean yellow mosaic India virus (MYMIV) which is a serious disease of blackgram, mungbean and soybean [10, 19]. In eastern India it was reported in the form of mungbean yellow mosaic India virus (MYMIV) infecting soybean (accession no. HF922628). The disease was successfully transmitted by whitefly (*Bemisia tabaci* Genn.). The whitefly, *Bemisia tabaci* Genn. has become devastating insect pest which suck the phloem sap from the lower surface of leaves and also play as a vector for transmission of mungbean yellow mosaic virus disease in soybean, blackgram and greengram [13]. The pest is polyphagous and is active throughout the year on different host plants depending upon regional ecological conditions. Losses in grain yield depend on the severity of the disease and sometimes all the plants are rendered podless, resulting in complete failure of the crop for seed production [6]. Subsequently, Nene [13] reported the disease causes 85-100% yield loss depending upon the susceptibility of the cultivar, time of infection, population of vector (*Bemisia tabaci*) and other favourable conditions. In India, the annual monetary losses in legumes (soybean, blackgram and mungbean) caused by yellow mosaic disease (YMD) have been estimated to be approximately US $300 million per year [20]. So the management of YMV is of immense important to reduce the crop loss and also to minimize the deterioration quality. Control of YMV in a particular region depends largely on the management of vector (*Bemisia tabaci*) population. So it needs in depth investigation on the relationship of whitefly population and prevalence of the virus on different soybean varieties. The present study was undertaken to find out the relationship of whitefly population with the prevalence of YMV on five soybean varieties under field condition.

2. Materials and Methods

The field experiments were conducted at the Horticultural Research Station (HRS) Mondouri (23.5º N latitude, 89º E longitude and 97 m above mean sea level) of Bidhan Chandra Krishi Viswavidyalaya (BCKV) in the consecutive year 2011 and 2012. Five soybean varieties namely, JS-335, JS-9305, KDSB-2042, KSL-441 and KSL-20 were included in the study. JS-335was received from Maharashtra Seed Certification Agency whereas the other four varieties *viz*., JS-9305, KDSB-2042, KSL-441 and KSL-20 were received from Krishidhan Seeds Pvt. Ltd., Maharashtra. Field trials were laid out in randomized block design (RBD) with four replications. Plots were 2.5×2.0 m2 sizes in all the trials. In each plot 40 cm row to row and 20 cm plant to plant spacing were maintained. Within a row, seeds were hand dibbled 20 cm apart. Standard package of practices was followed to raise the crop. The fertility regime included two applications at the time of sowing and four weeks after sowing. Farm yard manure was applied @ 10 t ha-1 in all the plots. The crop was fertilized with 20 kg nitrogen, 80 kg phosphate and 50 kg potash per hectare at four weeks after planting. Ten competitive plants were randomly selected from each variety in each replication and data were recorded.

The plants were inspected every day morning to monitor the population dynamics of whitefly and to note the appearance and development of the symptoms of yellow mosaic disease (YMD). The population count of whitefly was taken at seven days intervals in ten randomly selected plants in each replicated plot. The incidence of the disease was recorded at periodic intervals started from 35 days after sowing to maturity stage. The rating on the YMV was done using the 0-5 arbitrary scale, as suggested by Bashir *et al.* [2] which was described in Table 1. Meteorological data were collected from AICRP on Agro-Meteorology, Directorate of Research, BCKV, Kalyani, Nadia.

Table 1. Disease Scoring Scale (0-5) for YMV

Severity	% Infection	Infection category	Reaction group
0	All plants free of virus symptoms	Highly resistant	HR
1	1-10% infection	Resistant	RR
2	11-20% infection	Moderately resistant	MR
3	21-30% infection	Moderately susceptible	MS
4	30-50% infection	Susceptible	S
5	More than 50%	Highly susceptible	HS

3. Results

3.1 Screening of YMV in Soybean varieties at Gangetic Alluvial Zone

The percentage intensity of yellow mosaic differed in different varieties during both year of study (2011 and 2012). Incidence ranged from 5.83 to 45.00% during first year and 7.50 to 44.17% during second year (Table 2). Among the five varieties screened the lowest incidence was recorded with variety JS-9305 followed by KDSB-2042. The variety JS-335 recorded the highest incidence followed by KSL-20 and KSL-441 during the study. On the basis of disease reaction classification, it was found that none of the test varieties appeared to be highly resistant, moderately susceptible or highly susceptible. Variety JS-9305 was resistant. KDSB-2042 was moderately resistant. Varieties JS-335, KSL-20 and KSL-441 were susceptible. Varieties which exhibited better tolerance against yellow mosaic gave better yield. The maximum estimated yield was recorded in the variety JS-9305 and the lowest yield was obtained in variety JS-335.

Table 2. Incidence of yellow mosaic virus (YMV) and grain yield of five varieties of soybean

Variety	2011			2012		
	YMV Infecting soybean	Yield (tha-1)	Reaction group	YMV Infecting soybean	Yield (tha-1)	Reaction group
JS-335	45.00 (42.13)*	2.13	S	44.17 (41.65)	2.23	S
JS-9305	5.83 (13.98)	2.75	RR	7.50 (15.89)	2.78	RR
KDSB-2042	15.00 (22.79)	2.63	MR	13.33 (21.42)	2.74	MR
KSL-441	35.00 (36.27)	2.25	S	36.67 (37.27)	2.27	S
KSL-20	37.50 (37.76)	2.21	S	38.33 (38.25)	2.27	S
SEm (±)	1.55	0.01		1.72	0.01	
CD at 0.05	4.78	0.03		5.30	0.05	

*Data parentheses are angular transformed value

3.2 Relationship of Temperature and Humidity with Whitefly population build-up in the field

3.2.1 Temperature

The field observation was carried out during second fortnight of June to first fortnight of October and whitefly was observed throughout the observation period for two years of study. The average temperature in the soybean field was 32.5ºC when the experiment was started (first fortnight of July), which increased to 33ºC in the next fortnight and then dropped down to 30.6ºC in the following 56 days. Within this period, the whitefly population per plant was 13 at the first 14 days to 18 in the subsequent 28 days and then declined to 11 in the next 28 days possibly due to the rainfall with decreasing temperature in the field. Moreover, the population of whitefly reached the peak up to 39 during 5th fortnight, when the temperature was 32.2ºC then declined to 6 at the last fortnight (Fig. 1A). A quadratic polynomial relationship between temperature and whitefly population build up in soybean field was observed as it is indicated by the equation ($y = -0.173x^2 + 11.06x – 175.5$ & $R^2 = 0.285$) where the R^2 value was low and the relationship was weak (Fig. 1B). The equation revealed that the whitefly population was maximum *i.e.,* 39 at 32.15ºC and beyond this temperature the population decreased at the rate of 0.173 for per unit changing of temperature.

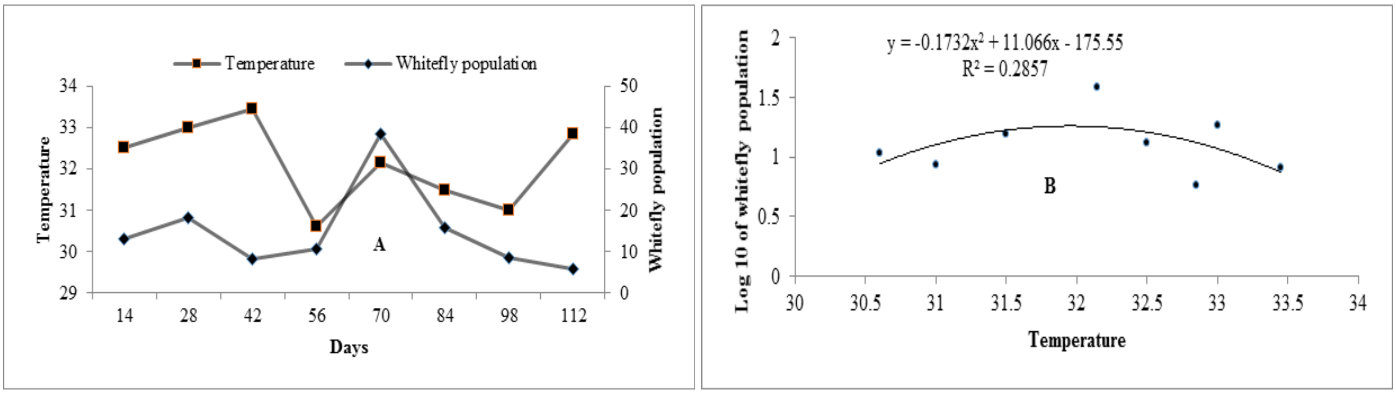


Fig 1: Whitefly population influenced by temperature (A) and relation between temperature and whitefly population (B) in the soybean field

3.2 Relative Humidity

It was observed that the fortnightly average relative humidity attained the value of 87.3 during 5th, 14 days *i.e.,* second fortnight of August which coincided with maximum whitefly population. After that whitefly population, gradually declined to 6 in the subsequent 42 days (Fig. 2A). In fig. 2B the equation ($y = -0.019x^2 + 3.517x - 154.5$&$R^2 = 0.678$) indicates a quadratic polynomial relationship between relative humidity and whitefly population build up in the soybean field. The relationship was somewhat significant but showed a negative trend indicating the negative effect of relative humidity on the whitefly population build up in the field. The whitefly population was recorded maximum *i.e.,* 39 at 87.3% relative humidity and beyond this relative humidity population decreased at the rate of 0.019 for per unit changing of relative humidity.

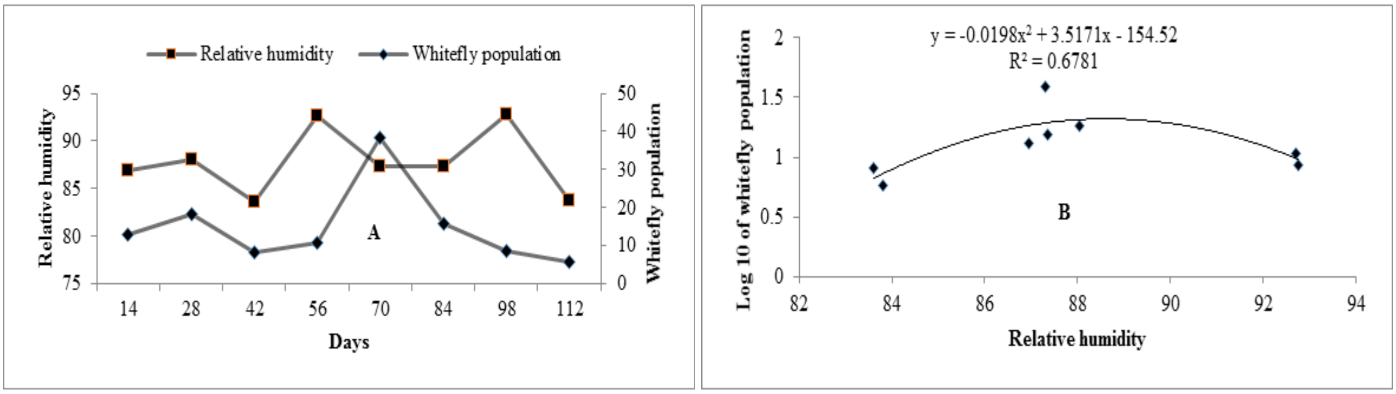
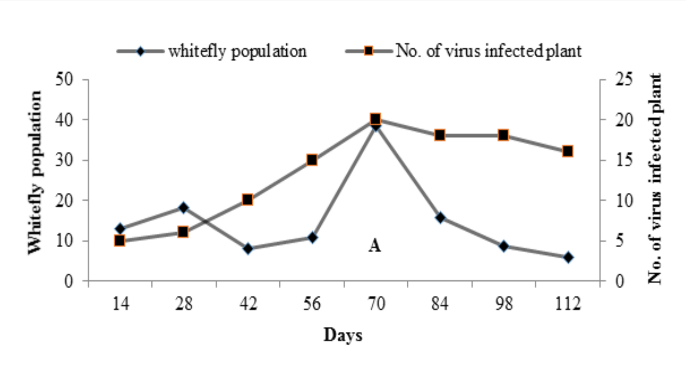


Fig 2: Whitefly population influenced by relative humidity (A) and relation between relative humidity and whitefly population (B) in the soybean field

3.3 Relationship between the whitefly populations build up and spread of YMV in soybean field

The numbers of whitefly caught in the field in every 14 days are presented in the Fig. 3A. It was observed that spread of YMV increased with increased number of whitefly population. When the number of whitefly population reaches its peak up to 39 and then the number of virus infected plant was the highest. After that the virus infection was in a static level but the whitefly population was gradually decreased. This might be due to the maturity of the plant, which did not favour the whitefly. A quadratic polynomial relationship between whitefly population builds up and spread of YMV in the field was found as indicated by the equation: $Y= 0.001x^2 - 0.055x + 1.498$ ($R^2 = 0.324$) where the R^2 value was low and the relationship was positive. The R^2 value indicates that about 32.4% of the disease spread can be explained by the whitefly population. The equation also suggested that the incidence of YMV in soybean was high and whitefly population reached to 39 and beyond this population, the disease spread increased at the rate of 0.001 for per unit changing of whitefly population (Fig. 3B).



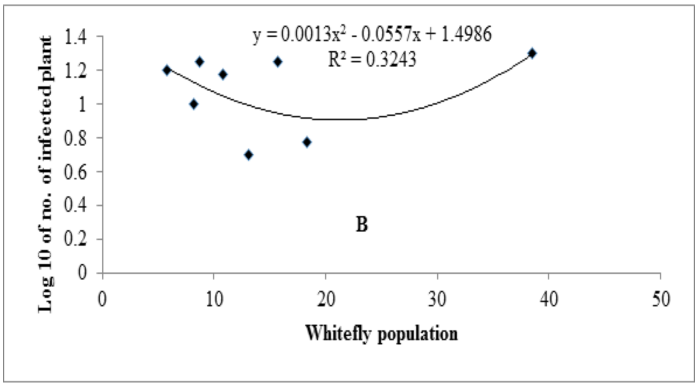


Fig 3: Spread of YMV infection in soybean field in relation to whitefly population (A) and relationship between whitefly population and virus infection (B).

4. Discussion

The relative grain yield of the varieties varied depending upon the disease intensity. The virus is also highly damaging in Bangladesh which may reach even up to 100% depending on the varieties and stage of infection and distributed all over the country [1, 5].

Butani and Jotwani [3] reported that activity of whitefly decreased in tomato with the onset of rains which is also in support to the results under present studies. Activity of whitefly population was gradually increased and reached at peak during 5th fortnight when the favourable weather parameters were occurred. Similar trends strongly supported with the findings of previous workers [9]. Purohit *et al.* [15] stated that the peak activity of whiteflies was observed during the 3rd week of September in cotton.

Rao and Chari [16] reported that maximum temperature had negative correlation with the incidence of whiteflies in cotton and tobacco crops. The negative correlation of whitefly population to temperature as found in present study is in conformity with the findings of previous workers [21]. Present results revealed that among the abiotic factors the temperature plays important role for oscillation of whitefly population which was strongly supported by the previous workers [11].

Rote and Puri [17] and Jagdev and Butter [7] reported that relative humidity was negatively correlated to population of whitefly. This findings are strongly supported with the present study. Similar findings reported that relative humidity was negative correlation with the incidence of whiteflies in cotton and tobacco crops [16]. Shrivastva and Prajapati [18] revealed that negative influence on whitefly population in blackgram (*Vigna mungo*). The negative correlation of whitefly population to relative humidity is in strongly supported with the findings of our present study [21]. Similar results was also reported that evening relative humidity was expressed negative correlation on influence of whitefly population in soybean [22].

Gibbs *et al.* [4] and Jeyarajan *et al.* [8] have considered such situation as a triggering factor in an epidemic simulation, if a population that follows bears a high degree of proneness. However, it is evident from the present observation that spread of YMV in soybean was increased with the high population of whitefly vector which further caused the secondary spread of the virus among the plants resulted high intensity of YMV infection.

5. Conclusion

The results obtained in the study revealed it was found that none of the five soybean varieties appeared to be highly resistant, moderately susceptible or highly susceptible. Variety JS-9305 showed the resistant against YMV infection. The temperature and relative humidity were weekly related with the whitefly population build up in the field. However, the increase of whitefly population in the field was positively correlated with spread of YMV.

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