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Survey for Resistant Sources and Correlation-regression Studies on Yellow Mosaic Disease (YMD) of Mungbean in Haryana, India

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ABSTRACT: During *Kharif*, 2020 a survey was conducted by using multistage random sampling technique for recording disease incidence of yellow mosaic disease of mungbean in three districts of Haryana *viz*., Hisar, Sirsa and Fatehabad. It was found that the highest mean disease incidence was recorded from village in Sirsa and least from location in Hisar district. Yellow mosaic disease produces the symptoms like small yellow specks, mosaic, chlorosis, stunting of plant, puckering of leaves, short flower stalks bearing few flowers and yellow pods with immature and shrivelled seeds. As the disease survey helps in estimating the losses caused by the disease. The disease incidence and whitefly population were recorded simultaneously from mungbean field to calculate the correlation as well as regression equation. Where the whitefly population was found to be positive and significantly correlated with disease incidence at 5% level of significance. The various weather parameters like temperature, rainfall, average wind speed, bright sunshine hours and relative humidity, govern 88.0% towards disease incidence when implied together (R^2 = 0.88). Studying the relation of weather parameters with the disease incidence will help in making a disease forecasting model that will further help in controlling the disease.

Keywords: Survey, Mungbean, Yellow mosaic disease, Disease Incidence, Correlation and Regression.

INTRODUCTION

Vigna radiata (L.) Wilczek is also known as green gram, mungu, moong, pachai payaru, golden gram and green soy (Abhisheka *et al*., 2020). It's a prominent pulse crop native to India or the Indo-Burmese region (Karthikeyan *et al*., 2014) and is a representative of the *Fabaceae* family. With a chromosomal number of 2n=22, it is a self-pollinated crop (Jyothi *et al*., 2020), and a rich source of easily digestible proteins and high in the amino acid lysine, which is generally scarce in cereals (Saminathan, 2013; Shahrajabian *et al*., 2019). More than two-thirds of the world's green gram is produced in India (Sivakumar *et al*., 2020). It is cultivated in India during three seasons *i.e*., *Kharif*, *Rabi* and Summer/Spring season (Jyothi *et al*., 2020).

Maharashtra, Gujarat, Tamil Nadu, Andhra Pradesh, Bihar, Uttar Pradesh, Rajasthan, Karnataka and Orissa are the key mungbean cultivating states in India (Dharajiya *et al*., 2018). It is cultivated in an area of around 4.58 million hectares in 2019-2020, yielding 2.50 million tonnes with a productivity of 548 kg/ha (Anonymous, 2020). During 2019-2020, Haryana's mungbean area was 0.2 lakh hectares, with a total production of 0.12 lakh tonnes and a productivity of 595 kg/ha (Anonymous, 2020). The yellow mosaic disease of mungbean causes upto 85 per cent grain loss (Sivakumar *et al*., 2020). The first report of yellow mosaic disease in India came from the IARI's mungbean experimental research farms in New Delhi (Nariani, 1960).

The Geminivirus (genus *Begomovirus*, family *Geminiviridae*), which has bipartite genomes (DNA A and DNA B) causes yellow mosaic disease. Whitefly (*Bemisia tabaci* Genn.) serves as its vector, spreading the virus from infected to healthy plants in a persistent circulative way. It can infect mungbean plant at any stage of its development (Nainu and Murugan, 2020; Reshmi Raj *et al*., 2020).

Small yellow spots develops first which later spreads across the leaf lamina, resulting in yellowing, chlorosis and followed by necrosis. The virus causes vein banding, internode shortening and plant stunting. As a result of the disease, the plant produces few blooms and thin, malformed pods (Meti *et al*., 2017). Early stage infections cause mosaic, puckering and complete yellowing symptoms which are more dangerous since, the crop is more vulnerable at that time (Salam *et al*., 2011). Disease causes systemic symptoms and also affects seed quality hence, reducing its output (Singh *et al*., 2020).

Various weather variables influence the survival and reproduction of the vector whitefly (*Bemisia tabaci*) as well as the onset of YMD in mungbean throughout the cropping season. As a result, in order to develop a disease predicting system, a fundamental understanding of weather variables and their impact on MYMV incidence is required. However, there are little studies on this topic and epidemiological aspects of YMD in Haryana.

Keeping this in view of the importance of the disease and lack of work done in Haryana. The survey and correlation-regression studies were further conducted during *Kharif*, 2020.

MATERIALS AND METHODS

Survey: Major mungbean growing areas (Hisar, Fatehabad and Sirsa) of Haryana were surveyed during *Kharif,* 2020. In these three districts of Haryana nineteen locations were surveyed (Table 1). Mungbean fields were selected randomly at each location in these districts. Locations in each district were randomly surveyed to record the disease incidence. The percent disease incidence was calculated using following formula (Mayee and Datar, 1985):

$$\text{Per cent disease Incidence} = \frac{\text{Number of infected plants}}{\text{Total no. of plants observed}} \times 100$$

Recording disease incidence against yellow mosaic disease (YMD) in mungbean: In the field experiment mungbean crop was sown in a row of 3 m length with spacing of 30 cm × 15 cm in three replications using randomized block design (RBD). Recommended cultural practices were followed to express genetic potential without insecticide sprays to maintain optimum whitefly (vector) population for high inoculum pressure of YMD pathogen. The crop was regularly monitored for development of symptoms of the disease. For recording yellow mosaic disease incidence, observations were recorded at an interval of one-week upto nine weeks after sowing. The equation for the PDI is as per Mayee and Datar (1985) mentioned above.

The whitefly population was recorded at weekly intervals throughout the croping season from beginning till the maturity of the crop (July-September). The observations with regard to number of whitefly (*Bemisia tabaci* Genn.) were recorded on three leaves, *viz*., one each from top, middle and lower portion of five randomly selected plants in a row. Recorded data was finally used to work out the average number of whiteflies per trifoliate leaf per plant by calculating the overall mean of the population (Patil *et al*., 2021).

Weather data that consisted of maximum and minimum temperature (°C), rainfall (mm), relative humidity (%), average wind speed (km/hr.), bright sunshine hours (hr.) were taken from Agro Meteorological Observatory, CCS HAU, Hisar, India.

Statistical Analysis: The data obtained from field experiments conducted using RBD with three replications was subjected to statistical analysis as per procedure of RBD (Gomez and Gomez, 1984) by using OPSTAT.

RESULTS AND DISCUSSION

During *Kharif*, 2020 in Haryana, 19 locations/villages from 8 blocks in the three major mungbean growing districts namely Hisar, Sirsa and Fatehabad were surveyed. Variable symptoms such as yellowing, stunting, crinkling, curling and puckering with bright yellow mosaic were also observed in the surveyed fields. The disease incidence varied in different fields within each location. The disease incidence ranged from 1 to 65 per cent (Table 1). The minimum disease incidence (1 per cent) was recorded from CCS Haryana Agricultural University's Pulses Research farm in Hisar district, while the maximum disease incidence (65 per cent) was observed in the Bhoona village of Sirsa district. The high disease incidence is attributed to the increased number of whitefly population observed in the field, as whitefly is the vector of the yellow mosaic disease and prevailing weather conditions favoured the disease. In Sirsa district, range of disease incidence varied from 25 to 65 per cent, in Hisar it was 1 to 60 per cent while, in Fatehabad, it was 10 to 22 per cent. Earlier Sivalingam *et al*., (2019) recorded the disease incidence range between 1.5 and 6.1 per cent during the survey in Chhattisgarh for studying the appearance of pigeonpea yellow mosaic disease (PYMD). Kumar *et al*., (2018) conducted survey for yellow mosaic disease in five districts of Rajasthan and found that highest mean disease severity and whitefly population were reported from Kota and Banswara, respectively while the minimum were recorded in Bundi district. Panduranga *et al*., (2012) conducted field surveys in two districts of Andhra Pradesh and found that incidence of MYMV was more in Warangal district during vegetative 49.6 per cent and flowering 57.70 per cent, stages in comparison to Khammam district, with 42.20 per cent and 50.62 per cent of disease incidence, respectively. During the survey fifteen genotypes *viz*., MH 421, BCM 18-1, PKV AKM 4, MH 318, IPM 604-1, Kopergaon, LGG 460, IPM 2-3, MH 1703, MH 1720, MH 1874, SKNM 1705, MH 1431, KM 2419 and MH 18-185 showed varied levels of resistance reaction to YMD.

No disease symptoms were observed in any of the genotype until one week old crop during the cropping season in 2020. Gradually, the symptoms of YMD started to appear on the leaves of young plants. Results showed that the disease incidence increased with time and increased maximally from 34^{th} Standard Meteorological Week to 35^{th} Standard Meteorological Week (SMW) after sowing followed by lesser increase in disease incidence upto 38^{th} SMW. No increase in disease incidence was observed during mature stage of the crop (Fig. 1).

Table 1: Survey of major districts growing mungbean in Haryana during *Kharif*, 2020.

Sr. No.	Districts	Village	Block	Latitude and Longitude	YMD Reaction	Percent Disease Incidence (%)	Variety	Location of Collection
1.	Sirsa	Randhawa	Sirsa	29.4209°N, 75.0713°E	MR	25	Unknown	Farmer's Field
2.	-do-	Nirwan	-do-	29.5321°N, 75.0318°E	MR	50	-do-	-do-
3.	-do-	Ding	Nathusari Chopta	29.4610°N, 75.2625°E	MR	40	-do-	-do-
4.	-do-	CRS	Sirsa	29.5424°N, 75.0396°E	MR	50	-do-	-do-
5.	-do-	Rupawas	-do-	29.3644°N, 75.0545°E	MS	60	-do-	-do-
6.	-do-	Gindran	Rania	29.6197°N, 74.7586°E	MR	40	Unknown	-do-
7.	-do-	Kharian	-do-	29.6200°N, 74.8580°E	MR	45	-do-	-do-
8.	-do-	Ghoranwali	-do-	29.6351°N, 74.7850°E	MR	44	-do-	-do-
9.	-do-	Bhoona	-do-	29.5365°N, 75.7108°E	MS	65	-do-	-do-
10.	Fatehabad	Jhandwala bagar	Bhattu Kalan	29.3119°N, 75.2610°E	R	10	MH 421	-do-
11.	-do-	Thuyan	Fatehabad	29.3400°N, 75.2844°E	R	20	-do-	-do-
12.	-do-	Bodiwali	-do-	29.4750°N, 75.2989°E	R	15	-do-	-do-
13.	-do-	Lehrian	Bhuna	29.6224°N, 75.7273°E	R	22	-do-	-do-
14.	Hisar	Bithmara	Hisar	29.5460°N, 75.9318°E	R	22	-do-	-do-
15.	-do-	Bugana	-do-	29.2581°N, 75.8316°E	R	25	-do-	-do-
16.	-do-	Budha khera	-do-	29.5020°N, 75.8853°E	R	22	-do-	-do-
17.	-do-	Bagla	Adampur	29.1891°N, 75.4723°E	R	20	-do-	-do-
18.	-do-	Kohli	-do-	29.2811°N, 75.5204°E	R	25	-do-	-do-
19.	-do-	CCSHAU	Hisar	29.1504°N, 75.7057°E	MR	25	BCM 18-1	Pulses Research Farm
20.	-do-	-do-	-do-	-do-	MR	26	PKV AKM 4	-do-
21.	-do-	-do-	-do-	-do-	MR	30	DGGV 91	-do-
22.	-do-	-do-	-do-	-do-	MR	30	MH 318	-do-
23.	-do-	-do-	-do-	-do-	MR	26	IPM 604-1	-do-
24.	-do-	-do-	-do-	-do-	MR	30	Kopergaon	-do-
25.	-do-	-do-	-do-	-do-	MR	30	LGG 460	-do-
26.	-do-	-do-	-do-	-do-	MR	26	IPM 2-3	-do-
27.	-do-	-do-	-do-	-do-	HR	1	MH 1703	-do-
28.	-do-	-do-	-do-	-do-	MS	51	IPM 312-394-1	-do-
29.	-do-	-do-	-do-	-do-	MS	55	IGM 06-18-3	-do-
30.	-do-	-do-	-do-	-do-	HR	2	MH 1720	-do-
31.	-do-	-do-	-do-	-do-	MR	30	MH 1874	-do-
32.	-do-	-do-	-do-	-do-	MR	26	SKNM 1705	-do-
33.	-do-	-do-	-do-	-do-	R	10	MH 1431	-do-
34.	-do-	-do-	-do-	-do-	MS	51	Pusa 1371	-do-
35.	-do-	-do-	-do-	-do-	MR	26	KM 2419	-do-
36.	-do-	-do-	-do-	-do-	MR	30	MH 18-185	-do-
37.	-do-	-do-	-do-	-do-	MS	55	MH 18-163	-do-
38.	-do-	-do-	-do-	-do-	MS	55	MH 18-189	-do-
39.	-do-	-do-	-do-	-do-	MS	51	OBGG 104	-do-
40.	-do-	-do-	-do-	-do-	MS	52	RMG 1139	-do-
41.	-do-	-do-	-do-	-do-	MS	60	MI 750-1	-do-

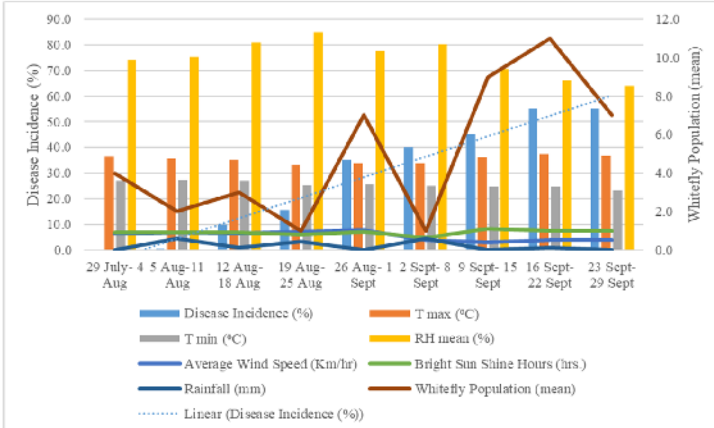

Fig. 1. Graphical representation of disease incidence and whitefly population with weather parameters during *Kharif*, 2020.

The results revealed that the disease begun to develop after two weeks of sowing, *i.e.*, during third week (33rd SMW). During 33rd SMW the disease incidence was 10 per cent and in 34th SMW it increased to 15.5 per cent indicating slow increase in disease incidence. Maximum disease incidence was found in 38th SMW (55 per cent) due to favorable weather conditions and maximum whitefly population. So, conclusion can be drawn that increase in whitefly population is directly proportional to the disease incidence. There was rainfall from 32th to 34th SMW and during 36th SMW as well 38th SMW. Hence, it can be concluded that increase in disease incidence from 34rh to 35th SMW and during 37th to 38th SMW can be due to no rainfall coupled with high maximum and minimum temperature as well as relative humidity and favorable environment for whitefly. The information on the development of YMD, whitefly population and weather parameters are shown in Table 2.

Table 2: Relation of disease incidence and whitefly population with weather parameters during *Kharif*, 2020.

SMW	Date	Disease Incidence (%)	Whitefly Population (mean)	T max (°C)	T min (°C)	RH mean (%)	Average Wind Speed (km/hr)	Bright Sun Shine Hours (hr.)	Rainfall (mm)
31	29 July- 4 Aug	0.0	4.0	36.5	27.2	73.9	6.2	6.9	0.0
32	5 Aug-11 Aug	0.5	2.0	35.7	27.5	75.1	6.8	6.8	4.4
33	12 Aug- 18 Aug	10.0	3.0	35.1	27.2	80.9	6.6	6.9	1.1
34	19 Aug- 25 Aug	15.5	1.0	33.1	25.2	85.0	7.1	6.0	3.4
35	26 Aug- 1 Sept	35.0	7.0	33.9	25.7	77.5	7.8	7.3	0.0
36	2 Sept- 8 Sept	40.0	1.0	33.8	25.1	80.1	4.0	4.8	4.6
37	9 Sept- 15 Sept	45.0	9.0	36.1	24.7	70.5	3.0	8.2	0.0
38	16 Sept- 22 Sept	55.0	11.0	37.6	24.6	66.2	3.8	7.6	1.0
39	23 Sept- 29 Sept	55.0	7.0	36.9	23.2	64.0	4.0	7.4	0.0

* SMW- Standard Meteorological Week

The correlation between disease incidence and whitefly population was found to be positive and significant (r = 0.689) at 5% level of significance. The disease incidence increases due to good buildup of whitefly population (Fig. 2). Present findings are in accordance with the results of Kumar *et al*., (2019) reported that the whitefly population was significantly and positively correlated with the disease incidence of mungbean yellow mosaic virus disease. Khan *et al*., (2018) also observed that there was a positive and significant correlation between whitefly population and disease incidence of the mungbean yellow mosaic virus disease as whitefly is the vector of the disease and the more its prevalence more will be the disease. Paul *et al*., (2011) reported that a positive and highly significant correlation exists between the whitefly population and disease incidence of YMD in mungbean. After calculating the correlation between disease incidence and various weather parameters (Table 3) it is concluded that disease incidence is positively but non significantly correlated with maximum temperature (r = 0.287) and bright sunshine hours (r = 0.263), is negatively and non-significantly correlated with the rainfall (r = -0.307) and the relative humidity (r = -0.594). It is negatively and significantly correlated with the minimum temperature (r = -0.909) and average wind speed (r = -0.720) at 1% and 5% level of significance, respectively. The findings of the current study are in consistent with those of various previous investigations like Patil *et al*., (2021) who reported that the maximum temperature (r = 0.003) was positively but non significantly correlated with the disease incidence. The morning (r = 0.463) as well as evening (r = 0.050) relative humidity and rainfall (r = 0.332) were non significantly correlated with the disease incidence. Khan *et al*., (2018) revealed that the disease incidence was negatively and significantly correlated with the wind speed. They also observed a negative relationship between disease incidence and the rainfall (mm), as hot weather with very less or no rainfall creates congenial conditions for good multiplication of Mungbean yellow mosaic India virus and the whitefly. While, Paul *et al*., (2011) found that a positive and non-significant correlation exist between maximum temperature and disease incidence.

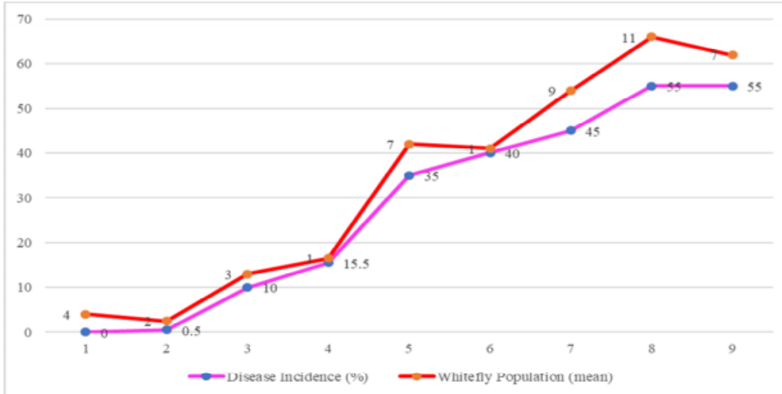

Fig. 2. Graphical representation of disease incidence in relation to whitefly population.

Table 3: Correlation between disease incidence and weather parameters.

	Disease Incidence (%)	Temperature max. (°C)	Temperature min. (°C)	Relative Humidity mean (%)	Average Wind Speed (km/hr)	Bright Sunshine Hours (hr.)	Rainfall (mm)
Disease Incidence (%)	1	0.287^{NS}	-0.909^{**}	-0.594^{NS}	-0.720^{*}	0.263^{NS}	-0.307^{NS}

* Significant at 5% level of significance, ** Significant at 1% level of significance, NS - Non-Significant

Regression equation is calculated in order to find out the relation of dependent variables disease incidence over the independent weather parameters *i.e.*, temperature maximum, temperature min., Relative humidity, average wind speed, bright sunshine hours and rainfall. From the final equation it is worked out that the bright sunshine hour is the only weather parameter which positively impacts the disease incidence. So, the weather parameters, govern 88.0 per cent towards disease incidence when implied together (R^2= 0.88). Earlier Patil *et al*., (2021) predicted that the variability in disease incidence can be upto 97.7 per cent due to various weather parameters.

$Y = 648.693 - 7.989 (X_1) - 7.473 (X_2) - 1.775 (X_3) - 4.05 (X_4) + 1.494 (X_5) - 0.875 (X_6)$

Coefficient of determination (R^2 value) = 0.88

Where

Y - Disease Incidence

X_1 - T max. (°C)

X_2 - T min. (°C)

X_3 - RH mean (%)

X_4 - Av. Wind Speed (km/hr)

X_5 - Bright Sunshine hours (hr.)

X_6 - Rainfall (mm)

Yellow mosaic disease is a prevalent and serious disease of mungbean in Haryana causing significant yield losses. Use of resistant varieties should be encouraged in order to reduce the losses caused by the disease. Also, the resistant genotypes can be used in breeding programmes in order to develop new advanced resistant lines. The reported observations of this study may add on to the previous information to devise a system to monitor, predict and develop management strategies in controlling the spread of mungbean yellow mosaic disease and the vector whitefly, *Bemisia tabaci* and also to screen resistant mungbean varieties for this disease in Haryana region.

From the present study it is concluded that out of the six weather parameters, only maximum temperature and bright sunshine hours are statistically positive but there is non-significant correlation with yellow mosaic disease outbreak. Increase in relative humidity, heavy rainfall, minimum temperature and wind speed is detrimental to whitefly population. These findings can be used to develop a disease forecasting model for judicious application of chemicals and control measures. So, the disease can be controlled prior to the severe infection and help in reducing yield losses and contributing to increase in farmer's income.

Conflict of Interest. None.

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