The Pharma Innovation Journal 2023; 12(2): 2803-2809

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(2): 2803-2809

www.thepharmajournal.com
Received: 27-12-2022
Accepted: 30-01-2023

Krittika Bharadwaj
Department of Plant Pathology, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali, Assam, India

Manoj Kumar Kalita
Department of Plant Pathology, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali, Assam, India

Ranima Mishra
Department of Plant Pathology, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali, Assam, India

Prarthna Rajkumari
Department of Entomology, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali, Assam, India

Budha Bora
Department of Plant Pathology, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali, Assam, India

Corresponding Author:
Krittika Bharadwaj
Department of Plant Pathology, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali, Assam, India

Influence of meteorological parameters on incidence of mungbean yellow mosaic virus disease in green gram in Assam

Krittika Bharadwaj, Manoj Kumar Kalita, Ranima Mishra, Prarthna Rajkumari and Budha Bora

DOI: https://dx.doi.org/10.22271/tpi.2023.v12.i2ah.18796

Abstract
Green gram (*Vigna radiata*) is one of the most important pulse crops grown in India and abroad bean yellow mosaic virus disease caused by Mung bean yellow mosaic virus has become a major threat in greengram cultivation in Assam. An experiment was conducted in the Experimental field, Department of Plant Pathology, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali during 2021-22, where green gram was sown in five dates starting from 5th September 2021to 3rd October 2021 at 7 days interval to study the effect of meteorological parameters in the incidence of green gram yellow mosaic virus disease, effect on growth and yield parameters so as to find out the best sowing time of the crop as a strategy for managing the disease. During the study, symptoms like, appearance of chlorotic specks along the veins, puckering of leaves, typical mosaic pattern, complete yellowing and drying of the leaves were recorded. Highest whitefly population (12.42 no/plant) was recorded in the crop sown on 19.09.2021 and the lowest (6.24no/plant) was recorded in the 05.9.2021 sown crop. Lowest (40.32%) disease incidence with highest seed yield (4.50 q/ha) was recorded in the crop sown on 05.09.2021, whereas highest (88.25%) disease incidence with lowest yield (2.50 q/ha) was recorded in the crop sown in second fortnight of September (19.09.21). Maximum temperature ranging from 29-33 ^{o}C, minimum temperature 13-23 ^{o}C with 8-9 bright sunshine hours were found to be conducive for incidence and rapid spread of the disease.

Keywords: Mungbean yellow mosaic virus, whitefly, dates of sowing, kharif season, growth and yield parameters

Introduction
Green gram (*Vigna radiata*) belonging to the family Leguminosae is one of the important pulse crops in India. It was originated in India and Central Asia. Besides India, green gram is also cultivated in Pakistan, Burma and Africa. India is one of the major producers of the crop in the world covering an area of 51.3 lakh hectares, with a production of about 30.85 lakh tones and with productivity of 601kg/ha (Anon, 2021a) [2]. In India, the major green gram producing states are Andhra Pradesh, Bihar, Karnataka, Rajasthan, Madhya Pradesh and Maharashtra (Anon, 2021b) [3]. Cultivation of green gram is limited by a number of biotic and abiotic factors. Among different diseases green gram, Yellow Mosaic Virus Disease has become a major threat in production of green gram in the recent years in India and also in Assam (Banerjee *et al.*, 2018) [5]. The crop loss ranges from 10-100 per cent depending on the genotype of green gram and the stage of crop at infection (Bashir *et al.*, 2006) [6].

Epidemiological studies on viral diseases especially those transmitted by insect vectors always have great bearing in establishing the virus-vector, virus-plant, and vector-plant interactions which helps in formulating effective management strategies. Although, the yellow mosaic virus disease of green gram is the most important constraint for production of green gram in Assam (Banerjee *et al.*, 2018) [5], report on systematic study on epidemiological factors that contribute to the development and rapid spread of the disease is very scanty. Therefore, in the present investigation attempt was made to carry out systematic study on the effect of different meteorological parameters on the incidence of yellow mosaic virus disease in greengram, effect of the disease on growth and yield attributes and to find out suitable sowing time to develop effective management strategy of the disease.

Materials and methods

Location and cultivation of green gram crop

The present investigation was carried out in the Post Graduate experimental field, Department of Plant Pathology, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali, Assam during 2021-2022 in a Randomized Block Design (RBD) with five dates of sowing having four replications. Green gram seeds of susceptible green gram variety K851 were sown at 7days interval starting from 5.09.2021 to 3.10.2021.

Symptomatology and recording of mungbean yellow mosaic disease incidence

The disease incidence and the development of typical symptoms of the disease were recorded at 10 days interval starting from 10 days after germination of seed. Disease incidence was calculated by using following formula given by Sridhar *et al.* (2013) [25].

$$\text{Per cent disease incidence} = \frac{\text{Total number of infected plants}}{\text{Total number of plants examined}} \times 100$$

Assessment of whitefly population

Ten plants per plot were randomly selected and the numbers of whiteflies were counted from the trifoliate leaves of three portions of the plant *viz.*, top, middle and bottom portion of leaves and average was calculated (Singh *et al.*, 2019) [23]. Counting of whitefly was done in the early morning and evening hours.

Effect of meteorological parameters on disease incidence

Data on various meteorological parameters such as maximum temperature, minimum temperature, total rainy days, wind speed relative humidity (morning and evening), sunshine hours and total rainfall for the period from September, 2021 to January, 2022 was collected from the Department of Agricultural Meteorology, Biswanath College of Agriculture, Assam. Parameters such as day temperature, night temperature and diurnal variation were derived as per formula given by Venkataraman and Krishnan (1992) [27].

Correlation Analysis

Simple correlation analysis was performed to determine the correlation between the disease and whitefly population also the disease various and the meteorological parameters. The formula below was used for correlation analysis

$$r = \frac{\sum xy}{\sqrt{(\sum x)^2(\sum y)^2}}$$

Where, r = correlation coefficient, x= disease incidence, y = whitefly population and meteorological parameters such as temperature (maximum and minimum), day and night temperature, total number of rainy days, relative humidity (morning and evening), wind speed, sunshine hours, and total rainfall

Regression analysis for development of disease prediction model

The effect of whitefly population and meteorological parameters on incidence of mungbean yellow mosaic virus disease was identified by multiple linear regression analysis. Based on the results, disease prediction model was developed. The multiple linear regressions used for the analysis is as follows-

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7X_7+\beta_8X_8+\beta_9X_9+\beta_{10}X_{10}+\beta_{11}X_{11}+\beta_{12}X_{12}$$

Where

Y= disease incidence(%), X_1= whitefly population, X2= temperature (maximum), X_3=temperature (minimum), X_4=day temperature, X_5=night temperature,X_6=diurnal variation, X_7=relative humidity (morning),X_8=relative humidity (evening),X_9=wind speed,X_{10}=sunshine hours,X_{11}=total rainfall,X_{12}=number of rainy days and βi=regression coefficients.

Effect of mungbean yellow mosaic virus disease on growth and yield attributing characters of green gram

The effect of mungbean yellow mosaic virus disease on growth and yield attributing characters of green gram such as plant height, number of branches per plant, number of seeds per pod,1000 seed weight and number of pods per plant were studied. Ten plants each of healthy and diseased was randomly selected for recording the data. Per cent reduction over healthy was calculated by using the formula given by Pathak, 2011 [17].

$$\text{\% reduction in growth and yield parameter} = \frac{\text{Parameters of healthy plants} - \text{Parameters of diseased plants}}{\text{Parameters of healthy plants}} \times 100$$

Effect of mungbean yellow mosaic virus disease in yield: Harvesting of green gram plants was done plot wise periodically at maturity and kept separately. Post-harvest operations such as winnowing and threshing were done and seed yield per plot was recorded and later converted to yield per hactare.

Results and Discussion

Symptomatology

In the present investigations symptoms like, appearance of minute yellow spots on the leaves (Plate 1), chlorotic specks along the vein (Plate 2), which later coalesced (Plate 3) and formed a mosaic pattern with puckering of leaves (Plate 4 - 6), complete yellowing (Plate 7) followed by drying of leaves (Plate 8) were observed in the green gram plants infected with green gram yellow mosaic virus. Most of these symptoms were also observed by earlier investigators. Nene (1973) [15] reported that green gram plants infected with mungbean yellow mosaic virus**,** developed greenish to yellowish patches in the older leaves and the younger leaves turned completely yellow in colour. Karthikeyan *et al.* (2014) [10] observed appearance of yellow specks along the veins together with thinning and curling of pods upwards.

Plate 1: Initiation of disease

Plate 2: Chlorotic specks along veins

Plate 3: Coalescing of specks

Plate 4: Mosaic pattern

Plate 5: Yellowing of leaves at seedling stage

Plate 6: Mosaic with puckering of leaves

Plate 7: Complete yellowing of leaves

Plate 8: Drying of leaves

Table 1: Effect of dates of sowing of green gram on whitefly population buildup, incidence of mungbean yellow mosaic virus disease and seed yield.

Date of sowing	Whitefly population (nos./plant)	Disease incidence (%)	Seed Yield (q/ha)
D1 (5.09.2021)	6.24	40.32 (39.40)	4.10
D2 (12.09.2021)	8.84	66.42 (54.56)	4.50
D3 (19.09.2021)	12.42	88.25 (69.92)	3.60
D4 (26.09.2021)	12.01	84.88 (67.09)	2.80
D5 (3.10.2021)	9.24	68.78 (56.00)	2.50
CD (0.05)	0.71	3.14	-

Figures in the parenthesis represent angular transformed values

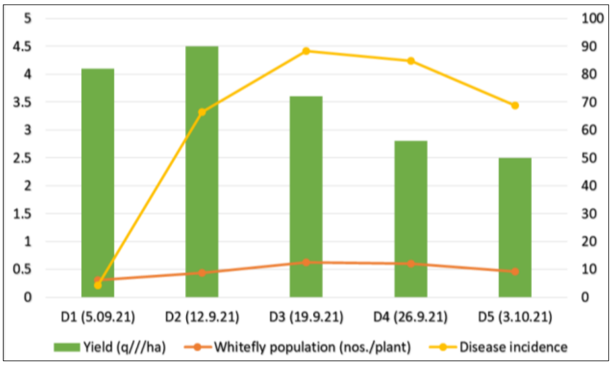

Fig 1: Effect of whitefly population, disease incidence on seed yield

Effect of dates of sowing on whitefly population build up

A perusal of result presented in table1 and Fig1 depicts that whitefly population (no/plant) build up varied in different dates of sowing. Highest whitefly population (12.42 no/plant) was recorded in the green gram plots sown on 19.9 2021 (D3) followed by the crop sown on 26.9.2021 (D4), 3.10.2021 (D5), 12.9.2021 (D2) with 12.01, 9.24, 8.84 number of whitefly per plant respectively and the lowest whitefly population (6.24 no/plant) was recorded in the crop sown on 05.9.2021 (D1). The whitefly population started building up from September sown crop, reaching its peak in the crop sown in the second fortnight of September and then started declining and minimum was recorded in the crop sown in the first week of October. The variation of whitefly population in different dates of sowing recorded in the present investigation may be due to variation of meteorological parameters prevailing during the cropping season. Similar to the present study, Adhikary et al. (2018) [1] also reported that whitefly population build up in the field is greatly influenced by prevailing meteorological parameters like temperature, relative humidity and rainfall. Singh et al. (2019) [23] observed that whitefly population in pulse crop increased gradually from the first week of August (32nd SMW), reached its peak in the first week of September (36th SMW) and started declining thereafter. They concluded that prevailing meteorological parameters had a major role on the whitefly population build up.

Effect of dates of sowing on the disease incidence

The result presented in table1 and Fig1 indicated that disease incidence was significantly influenced by the dates of sowing. Highest (88.25%) disease incidence was observed in the crop sown on 19th September, 2021 (D3) and the lowest (40.32%) in the crop sown on 5th September, 2021 (D1). Concurrent with the present observations, earlier investigators also observed variation in disease incidence as 4 to 40 per cent (Bashir et al., 2006) [6], 8-100 per cent (Pawar and Mahatma, 2013) [19], 42.20 to 57.70 per cent (Panduranga et al., 2012) [16], 1.29 to 45.46 per cent (Singh and Padwal, 2019), 4.85 to 15.5 per cent and 1.1 to 47.8 per cent (Patil et al., 2021) in different locations. Rashid et al. (2013) recorded highest disease incidence in the crop sown in April, and the lowest disease incidence was recorded in the plots sown in January. The variation in disease incidence was to be correlated with the whitefly population build up in different dates of sowing. Highest whitefly population in D3 also resulted in highest disease incidence and lowest whitefly population in D1 resulted in lowest incidence of the disease

Table 2: Correlation matrix for mungbean yellow mosaic virus disease incidence with whitefly (*Bemisia tabaci*) population and weather variables in relation to different dates of sowing of green gram during 2021

Dates of sowing	Whitefly	Tomax	Tmin	Bssh	Rf	RH(M)	RH(E)	WS	Day T	Night T	DV	No. of Rainy days
D1	0.963***	-0.410	-0.594	0.226	-0.558	-0.468	-0.326	-0.462	-0.504	-0.540	0.633	-0.235
D2	0.929***	-0.691	-0.713*	0.453	-0.575	-0.562	-0.394	-0.266	-0.707*	-0.710*	0.699	-0.382
D3	0.985***	-0.906***	-0.819**	0.392	-0.150	-0.135	-0.336	-0.043	-0.862**	-0.845**	0.706*	-0.015
D4	0.992***	-0.783*	-0.869**	0.770*	-0.568	-0.440	-0.404	-0.116	-0.849**	-0.860**	0.859**	-0.491
D5	0.993***	-0.964***	-0.975***	0.210	-0.236	-0.321	-0.321	0.362	-0.988***	-0.987***	0.847**	0.029

*Significant, **Moderately significant, *** Highly Significant

Table 3: Correlation matrix for whitefly (*Bemisia tabaci*) population with weather variables in relation to different dates of sowing during 2021

Dates of sowing	Tomax	Tmin	Day T	Night T	BSSH	RF	WS	RH(M)	RH(E)	D.V	No. of Rainy days
D1	-0.210	-0.422	-0.312	-0.354	0.225	-0.558	-0.974***	0.468	0.168	0.610	-0.444
D2	-0.408	-0.425	-0.420	-0.422	0.221	-0.533	-0.46515	0.467	-0.537	0.422	-0.315
D3	-0.863**	-0.747*	-0.801**	-0.779*	0.314	-0.131	-0.10454	-0.072	-0.196	0.613	0.046
D4	-0.779*	-0.837**	-0.827**	-0.833**	0.746	-0.434	-0.085	-0.697	-0.302	0.810**	-0.719
D5	-0.926***	-0.973***	-0.970***	-0.975***	0.292	-0.239	0.385	-0.390	-0.304	0.880**	-0.005

*Significant, ** Moderately significant, *** Highly Significant

presented in table 2 clearly indicated that whitefly population had a significant positive correlation with the disease incidence. Among meteorological parameters, diurnal variation and bright sunshine hours shared a positive non-significant correlation with disease incidence, whereas, Maximum temperature, minimum temperature, day temperature and night temperature had significant negative correlation with disease incidence Other meteorological parameters, *viz*., relative humidity (morning), relative humidity (evening), total rainfall, wind speed and number of rainy days exhibited negative correlation with the disease incidence. In accordance to the findings of the present study, earlier Chahal *et al*. (2009) [8] observed a negative correlation between yellow mosaic virus disease incidence and meteorological parameters such as maximum and minimum temperatures and a positive non-significant correlation with bright sun shine hours. Singh and Padwal (2019) [24] observed a positive significant correlation between whitefly population and yellow mosaic virus disease incidence.

Effect of meteorological parameters on whitefly population

From table 3, it is clearly evident that Whitefly population was positively correlated with diurnal variation and bright sun shine hours and negatively correlated with maximum temperature, minimum temperature, wind speed, day temperature, night temperature, total rainfall, number of rainy days, relative humidity (Morning) and relative humidity (Evening). A negative significant correlation was observed between whitefly population and maximum, minimum, day and night temperatures towards the later dates of sowing [D3 (19.9 2021), D4 (26.9.2021) and D5 (3.10.2021)]. Similar to the present investigation, Sarmah *et al*. (2017) [21] also observed a negative significant correlation between whitefly population and maximum temperature, a negative non-significant correlation with minimum temperature but a positive non-significant correlation with Bright Sun shine hours. Meti and Kenganal (2018) [29] observed the least whitefly population during 40th and 39th SMW when the weekly mean maximum temperature was 28.9 °C and 30.4 °C, minimum temperature 22.8 °C to 22.2 °C and total weekly rainfall was 60.8 mm for 4 days respectively. They recorded highest number of whiteflies during 50th SMW having 29.7 °C maximum temperature. 16.7 °C minimum temperature and rainfall of 8.2 mm. Patil *et al*. (2021) [18] revealed that whitefly population shared a negative non-significant correlation with rainfall and relative humidity (14 hrs). These reports are in conformity of the findings of the present investigation.

Table 4: Regression equation for mungbean yellow mosaic virus disease incidence with whitefly (*Bemisia tabaci*) population and weather variables in relation to different dates of sowing

Dates of sowing	Regression equation ($Y= a+b_1X_1+b_2X_2+.+b_nX_n$)	R^2
D1(5.09.2021)	Y = -15.59+17.78X1	0.90
	Y = 20.96+16.00X1-1.43X3	0.94
D2(12.09.2021)	Y = -42.64+27.96X1	0.82
	Y = 15.31+23.00X1-2.04X3	0.97
D3(19.09.2021)	Y = - 37.01+24.62X1	0.96
	Y = -6.83+21.08X1-0.91X3	0.97
D4(26.09.2021)	Y = -53.75+30.23X1	0.98
	Y = -53.13+26.27X1+5.03X6	0.99
D5(3.10.2021)	Y = -30.56+24.11X1	0.98
	Y = 29.90+15.11X1-1.52X5	0.99
Kharif, 2021	Y = -30.80+23.65X1	0.93
	Y = 14.47+19.78X1-0.17X3-1.21X4	0.96

Prediction of disease

Multiple regression equation were developed for prediction of the mungbean yellow mosaic virus disease by taking into account whitefly population and meteorological parameters *viz*. maximum temperature, minimum temperature, day temperature, night temperature, diurnal variation, relative humidity (morning and evening), total number of rainy days, bright sunshine hours, wind velocity and total rainfall. The whitefly population was found to be the most important contributing factor for developing the disease prediction equation. Data presented in Table 4 clearly showcased that in different dates of sowing, disease incidence could be predicted up to 90-98 per cent when only whitefly population was taken into consideration. When a highly correlated meteorological parameter was added, the prediction was improved up to 94-99 per cent. Similar to the present investigation, Srivastava and Prajapati (2012) [26] reported that green gram yellow mosaic virus disease could be predicted up to 65 per cent when whitefly population and meteorological parameters such as minimum temperature, relative humidity (afternoon) and rainfall were taken into consideration.

Binyamin *et al.* (2022) [7] concluded that when weather parameters such as sub optimum temperature, relative humidity, optimum temperature, rainfall and wind speeds are taken into account the disease could be predicted accurately up to 83 per cent. Data presented in Fig.2 clearly indicate that the predicted values fluctuated around the observed values with non-significant error as such it could be inferred that whitefly population) was the most important factor for developing disease prediction model.

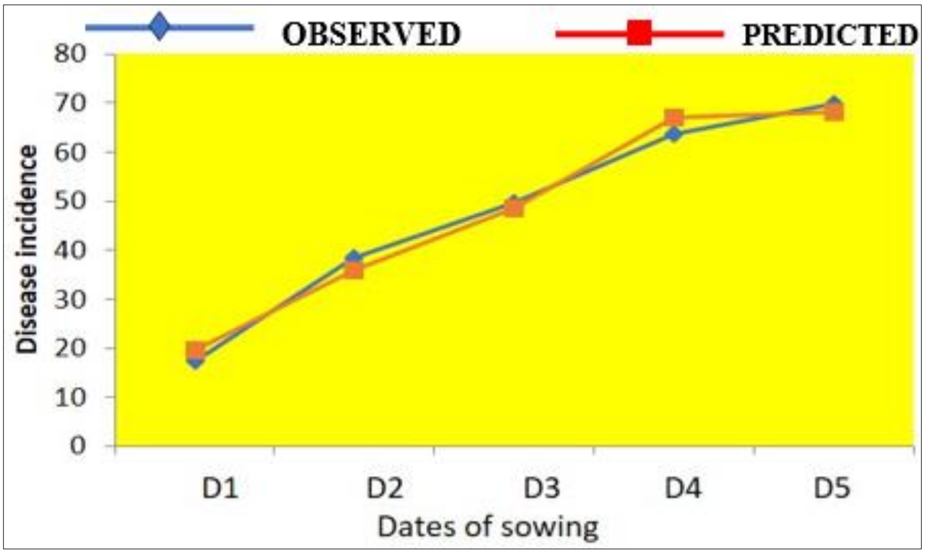

Fig 2: Observed and predicted green gram disease for *kharif* season

Table 5: Effect of Green gram yellow mosaic virus disease on growth parameters of green gram under different dates of sowing

Date of Sowing	Plant height (cm)			No. of branches/ plant		
	Healthy	Diseased	Reduction (%)	Healthy	Diseased	Reduction (%)
D1 (5.09.2021)	60.76	41.20	32.32(34.63)	18.13	13.92	23.22(28.80)
D2 (12.09.2021)	62.63	35.79	42.77(40.83)	18.60	12.88	30.75(33.66)
D3 (19.09.2021)	65.46	37.03	43.47(41.23)	20.93	13.70	34.55(35.98)
D4 (26.09.2021)	54.19	24.55	54.70(47.68)	16.90	11.02	34.54(35.98)
D (3.10.2021)	54.22	22.405	58.67(49.97)	14.65	9.8	33.10(35.10)
CD (p=0.05)	4.61	4.96	3.30	0.82	2.02	NS

Table 6: Effect of mungbean yellow mosaic virus disease on yield attributing parameters under different dates of sowing

Date of sowing	No. of pods/ plant			No. of seeds/ pod			1000 seed weight (g)		
Dates of Sowing	Healthy	Diseased	Reduction (%)	Healthy	Diseased	Reduction (%)	Healthy	Diseased	Reduction (%)
D1 (5.09.2021)	22.5	16.4	27.45 (31.58)	12.03	10.85	9.62 (18.06)	45.15	40.65	9.96 (18.39)
D2 (12.09.2021)	24.38	14.95	38.60 (38.39)	12.2	10.95	10.23 (18.65)	46.50	42.58	8.43 (16.88)
D3 (19.09.2021)	25.7	10.78	58.05 (49.61)	12.52	6.83	45.44 (42.37)	46.83	40.65	13.19 (21.29)
D4 (26.09.2021)	12.13	6.30	48.03 (43.85)	9.25	6.30	31.77 (34.30)	44.9	41.3	8.08 (16.51)
D5 (3.10.2021)	8.8	3.28	62.14 (52.01)	8.70	3.43	60.74 (58.18)	27.1	24.28	10.40 (18.80)
CD (p=0.05)	0.93	3.26	6.89	1.39	0.94	0.16	5.77	0.04	NS

Figures in the parenthesis represent angular transformed values

Effect of mungbean yellow mosaic virus disease on growth and yield attributing characters of green gram

Results presented in Table 5 and 6 clearly revealed that green gram crop sown in second week of September, 2021[D2(12.09.2021)] performed the best in respect of growth and yield attributing characters like plant height, number of branches/plant, no. of pod/plant, no. of seeds/pod, 1000 seed weight.

Effect on Growth characters

Plant height

Incidence of mungbean yellow mosaic virus disease resulted in the reduction of plant height which varied from 32.32 to 58.67 per cent over control in different dates of sowing. Highest (58.67%) reduction in plant height was observed in D5 (3.10.2021) and lowest (32.32%) in D1 (5.9.2021). Similar to present findings, Singh (1981) [22] reported up to 38.2 per cent reduction in plant height of mungbean. Khattak *et al.* (2000) [12] recorded reduction in plant height ranging from 18.5 to 40.5 per cent due to green gram yellow mosaic virus disease infection.

Number of branches/plant

Mungbean yellow mosaic disease considerably reduced the number of branches per plant as compared to healthy plant which varied among the five dates of sowing Highest (34.55%) reduction in number of branches per plant was recorded in D3 (19.9.2021) and the lowest (23.22%) in D1 (5.9.2021). Similar results were obtained by Zeshan *et al.* (2019) [28] who recorded 22.01- 43.46 per cent reduction in number of branches per plant due to infection by the disease.

Effect on Yield attributing characters

Number of pods/ plant

The green gram yellow mosaic disease significantly reduced the number of pods in the infected plant as compared to healthy plant which varied among the five dates of sowing. The crop sown on first week of October (3.10.2021) recorded the highest (62.14%) reduction in number of pods per pant over healthy and lowest (27.45%) on crop sown in the first week of September (5.09.2021). Similar to the result of present investigation, Ayub *et al.* (1989) [4] reported 91.6 per cent reduction in number of pod per plant. Likewise, Khattak *et al*. (2000) [12] reported 11.7 to 64.0 per cent reduction in number of pods per plant due to infection of green gram yellow mosaic virus.

Number of seeds per pod

Green gram yellow mosaic disease considerably reduced the number of seeds per plant as compared to the healthy plants which varied among the five dates of sowing. Highest (60.74%) reduction in the number of seeds per plant as compared to the healthy plants was recorded in D5 (3.10.2021) and lowest (9.62%) was recorded in D1 (5.9.2021). In earlier studies, Ayub *et al.* (1989) [4] reported upto 56.6 per cent reduction in number of seeds per plant due to incidence of green gram yellow mosaic disease and reported upto 18.5 to 82.2 percent by Khattak *et al*. (2000) [12].

1000 seed weight

The infection also resulted in reduction in 1000 to the tune of 8.08 to 13.19 per cent over healthy in different dates of sowing Highest (13.19%) reduction in 1000 seed weight over healthy was observed at D3 (19.9.2021) and lowest (8.08%) was recorded at D4 (26.9.2021). Similar to the present findings, Khattak *et al*. (2000) [12] observed that per cent reduction in 1000 seed weight over healthy was 10.6 to 53.3 and 35.41-49.94 per cent by Zeshan *et al*. (2019) [28].

Seed yield

Dates of sowing of green gram besides having impact in the incidence of green gram yellow mosaic disease also affected the yield of green gram. Data depicted in table1 showed that green gram sown on 12.9.2021 (D2) recorded the highest seed yield of 4.5q/ha and the lowest (2.8q/ha) the crop sown on 3.10.2021 (D5). From Fig1 it can be inferred that amount of disease incidence had a direct bearing in the seed yield of green gram. Although the disease incidence was slightly more as compared to D1 but the crop sown in this date had better plant growth and yield attributing characters which resulted in more seed yield as compared to other dates of sowing. In earlier studies, Meti and Kenganal (2018) [29] recorded highest yield of 1220 kg/ha when the green gram crop was sown in 6.6.2016 and lowest yield of 112kg /ha was observed in the crops sown in 4.7.2018Naveed *et al*., 2015 recorded highest (1990 kg/ha) seed yield on the crop sown in 2.6.2011 and the lowest (224 kg/ha) in 14.7.2011. All these earlier findings corroborates the present finding where higher seed yield of green gram was recorded in crop sown in the second week of September, 2021.

Conclusion

In the present investigation lower whitefly population and disease incidence was observed in the green gram crop sown up to the first fortnight of September along with better yield of green gram. Therefore, to avoid heavy incidence of mungbean yellow mosaic virus disease and to obtain better yield, the crop can be sown in the first fortnight of September in Assam. Population of the whitefly (*Bemisia tabaci* Genn.) vectoring the disease plays a significant role in the transmission and spread of the disease. More is the whitefly vector in the fields more incidence of the disease. In addition to whiteflies, weather parameters *viz*. maximum and minimum temperature, day and night temperature, diurnal variation etc. also play an important role in making the environment conducive for the rapid spread of the disease. Maximum temperature ranging from 29-33 °C, minimum temperature 13-23 °C with 8-9 bright sunshine hours were found to be conducive for incidence and rapid spread of the disease. The whitefly population was found to be the most important contributing factor for developing the disease prediction equation. More of these types of experiments must be carried out in various agro-climatic regions in order to fully verify the results regarding the best time of sowing the crop according to the area and to develop efficient integrated management strategies against the disease in order to obtain the highest yield.

References

1. Adhikary NK, Barma P, Tarafdar J, Saha G. Relationship of whitefly population build up with the spread of yellow mosaic virus on soybean. Journal of Entomology and Zoology Studies. 2018;6(5):348-352.
2. Anonymous Directorate of Economics and Statistics. 12 June, 2022; c2021a.
3. Anonymous. Green gram Outlook Report – January to May 2021. c2021b. https://angrau.ac.in/downloads/AMIC/GREENGRAM%20OUTLOOK%20REPORT%20-January%20to%20May%202021.pdf. 10 June, 2022.
4. Ayub MA, Ilyas MB, Bhatti MAR. Growth responses of mungbean cultivars to mungbean yellow mosaic virus infection. Pakistan Journal of Phytopathology. 1989;1(1-2):38.
5. Banerjee A, Umbrey Y, Yadav RM, Roy S. Molecular evidence of an isolate of mungbean yellow mosaic India virus with a recombinant DNA B component occurring on mungbean from mid-hills of Meghalaya, India. Virus disease. 2018;29(1):68-74.
6. Bashir M, Ahmad Z, Mansoor S. Occurrence and distribution of viral diseases of mungbean and mashbean in Punjab, Pakistan. Pakistan Journal of Botany. 2006;38(4):1341.
7. Binyamin R, Ahmed N, Ashraf W, Li Y, Ghani MU, Zeshan MA, *et al*. Prediction of mungbean yellow mosaic virus disease using multiple regression models. Journal of King Saud University- Science. 2022, 34(5).
8. Chahal S, Dhaliwal L, Kaur L, Singh S. Incidence of yellow mosaic virus as influenced by weather in moong. Journal of Agrometeorology. 2009;11:146-149.
9. Hussain A, Khalil SK, Khan S, Khan H. Effect of sowing time and variety on grain yield of mungbean. Sarhad Journal of Agriculture. 2004;20(4):481-484.
10. Karthikeyan A, Shobhana VG, Sudha M, Raveendran M, Senthil N, Pandiyan M, et al. Mungbean yellow mosaic virus (MYMV): a threat to green gram (*Vigna radiata*) production in Asia. International Journal of Pest Management. 2014;60(4):314-324.

11. Kaur L, Singh G, Sharma YR, Dhaliwal LK, Kaur S. Meteorological factors influencing mungbean yellow mosaic virus epidemic in mungbean. Plant Disease Research. 2009;24(1):81-82.
12. Khattak GSS, Haq MA, Rana SA, Abass G, Irfag M. Effect of Mungbean yellow mosaic virus (MYMV) on yield and yield components of Mungbean (*Vigna radiata* (L.) Wilczek). Agriculture and Natural Resources. 2000;34(1):12-16.
13. Bhuiyan MSH, Islam MS, Roy TS, Karim MA, Munsur MAZA. Mungbean and weed growth as affected by potassium and weed control methods. Int. J Res. Agron. 2020;3(2):01-08.
14. Naveed M, Shafiq M, Rafiq CM, Saeed MS. Planting date effects on the incidence of mungbean yellow mosaic virus (MYMV) and cultivars performance under rainfed environments. Plant Knowledge Journal. 2015;4(1):7-12.
15. Nene YL. Control of *Bemisia tabaci* Genn. a vector of several plant viruses. Indian Journal of Agricultural Sciences.1973;43(5):433-436.
16. Panduranga GS, Reddy PK, Rajashekara H. Survey for incidence of mungbean yellow mosaic virus (MYMV) in mungbean *Vigna radiata* (L.)Wilczek. Environment and Ecology. 2012;30(3):1030-1033.
17. Pathak DM. Epidemiology, transmission, biochemical changes and management of phyllody of sesame (*Sesamum indicum* L.). PhD thesis Junagadh Agricultural University, Gujarat, India; c2011.
18. Patil V, Singh PP, Kumar R, Kumar P. Population Dynamics of Whitefly and Incidence of Yellow Mosaic Virus Disease on Mung Bean in Relation to Abiotic Factors in Bihar, Indian Journal of Experimental Biology. 2021, 24: 475-479.
19. Pawar DM, Mahatma L. Occurrence and symptomatology of mungbean yellow mosaic virus (MYMV) in mungbean [*Vigna radiata* (L.) Wilczek] in south Gujarat. Asian Journal of Biological Sciences. 2013;8(2):237-240.
20. Rashid MH, Aktar MS, Hossain I, Rahman MM, Hasnat MR, Nair RM. Effect of dates of sowing on incidence and severity of Mungbean Yellow Mosaic Virus and Cercospora Leaf spot of mungbean. International Journal of Advanced Research and Technology. 2013;2(9):96-105.
21. Sarmah D, Rahman S, Debnath P, Khound A. Influence of weather factors on insect and mite pests infesting French bean (*Phaseolus vulgaris* L.), Assam, India. International Journal of Plant Protection. 2017;10(1):157-166.
22. Singh JB. Effect of viruses on growth components and yield of mungbean (*Vigna radiata*) and urdbean (*Vigna mungo*). Indian Phytopathology. 1981;33(7):405-408.
23. Singh M, Bairwa DK, Jat BL. Seasonal incidence of sucking insect pests of green gram. Journal of Entomology and Zoology Studies. 2019;7(2):654-658.
24. Singh SK, Padwal KG. Relationship of Whitefly, *Bemisia tabaci* Population and Mungbean Yellow Mosaic Virus Disease Incidence in Green Gram. International Journal of Current Microbiology and Applied Sciences. 2019;8:94-97.
25. Sridhar D, Patil MS, Palakshappa MG. Survey for sesame phyllody disease in Northern Karnataka. Karnataka Journal of Agricultural Science. 2013;26(2):320-321.
26. Srivastava AK, Marabi RS, Bal LM. Weather based rules for yellow mosaic disease prediction on soybean in Madhya Pradesh. Indian Journal of Biochemistry and Biophysics. 2021;58:486-497.
27. Venkataraman S, Krishnan A. Crops and Weather. Indian Council of Agricultural Research, Pusa, New Delhi. 1992, 302.
28. Zeshan MA, Ali S, Ahmed N, Yousaf M, Binyamin R. Description of Growth and Yield Parameters of Mungbean Cultivars Under Mungbean Yellow Mosaic Virus (MYMV) stress conditions. Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Science. 2019;35(2):93-97.
29. Meti M, Kenganal M. Influence of Dates of Sowing on Incidence of Mungbean Yellow Mosaic Virus (MYMV) in Mungbean, International Journal of Current Microbiology and Applied Sciences. 2018;7(9):2362-2367.