RESEARCH ARTICLE Legume Research- An International Journal, Volume 46 Issue 7: 934-939 (July 2023)

Morpho-physiological and Biochemical Variability in Greengram [*Vigna radiata* (L.) Wilczek] Varieties for Mungbean Yellow Mosaic Virus (MYMV) Resistance under Natural Field Conditions

G. Ramarao[1], J. Satishbabu[1], N. Harisatyanarayana[1], M. Adinarayana[1]

10.18805/LR-4534

ABSTRACT

Background: Mungbean yellow mosaic virus (MYMV) is economically most important disease of greengram reducing grain yields by 20-70%. Whiteflies and thrips are the most important insect pests which transmit the viral diseases MYMV and LCV respectively. The host plant resistance to MYMV disease in greengram genotypes has a great importance. The morpho-physiological and biochemical traits play an important role in host plant resistance against MYMV disease through insect vector resistance.

Methods: A field experiment was conducted during *rabi* 2017-18 and 2018-19 at RARS Lam Guntur in a randomized block design with eight greengram genotypes and replicated thrice under receding soil moisture condition. The experiment was conducted using eight greengram varieties (WGG 42, Pusa Vishal, LGG 607, LGG 630, LGG 601, LGG 610, LGG 460 and LGG 450) obtained from RARS Lam Guntur and the genotype LGG 450 was considered as a susceptible check. The estimation of sugars, phenols, tannins, trichome density and SCMR was done at vegetative and reproductive stages of crop growth.

Result: A significant variation was observed among the varieties for all the traits observed at vegetative and reproductive growth stages during both *rabi* 2017-18 and 2018-19. The total sugar content of the greengram varieties varied from 25.55 to 47.32 mg g^{-1} FW; the leaf phenolic content values ranged from 12.09 to 26.83 mg g^{-1} FW and the tannins content of the dried leaf samples ranged from 0.020 to 0.055 mg g^{-1} DW. The Trichome density of the greengram varieties varied from 75 to 162/cm^2 of leaf area and the SCMR values ranged from 35.12 to 58.67. Higher seed yield was recorded in the variety LGG 630 followed by WGG 42 and the lower seed yield was recorded in the variety LGG 450 during *rabi* 2017-18 and 2018-19. The MYMV resistant varieties showed relatively higher phenolic, tannins content and trichome density and lower total sugar content in the leaf. The total sugar content showed a significant negative correlation with the seed yield. The SCMR value was significantly lower in the susceptible varieties of greengram with higher disease scores.

Key words: Biochemical variability, Greengram varieties, Morpho-physiological traits, MYMV resistance.

INTRODUCTION

Greengram is one of the most important pulse crop grown in India after pigeonpea, chickpea and blackgram. Greengram is popularised by the name moong and mungbean. It is an important legume food crop because of its high protein, dietary fibres, vitamins and mineral contents. It is highly adaptable to a wide range of environmental conditions which favours it to grow under varied climatic conditions.

The wider adaptability of greengram is affected by both biotic and abiotic stresses. The biotic stresses include the complex viral diseases that are being transmitted by their insect vectors. In India, the major viral diseases that affect the mungbean production are mungbean yellow mosaic virus disease (MYMV) transmitted by whitefly, Urdbean Leaf crinkle virus (ULCV) transmitted by both aphids and whitefly and Leaf curl virus disease (LCV) transmitted by thrips. Among the three diseases MYMV is of highly important causing significant yield losses of 22.3-61.7% and might cause 100% yield losses when the disease appear in the early stages (Yadav and Brar, 2010).

[1]Regional Agricultural Research Station, Lam, Acharya NG Ranga Agricultural University, Guntur-522 034, Andhra Pradesh, India.

Corresponding Author: G. Ramarao, Regional Agricultural Research Station, Lam, Acharya NG Ranga Agricultural University, Guntur-522 034, Andhra Pradesh, India.
Email: rrgutha@yahoo.com

How to cite this article: Ramarao, G., Satishbabu, J., Harisatyanarayana, N. and Adinarayana, M. (2023). Morpho-physiological and Biochemical Variability in Greengram [*Vigna radiata* (L.) Wilczek] Varieties for Mungbean Yellow Mosaic Virus (MYMV) Resistance under Natural Field Conditions. Legume Research. 46(7): 934-939. doi: 10.18805/LR-4534.

Submitted: 28-10-2020 **Accepted:** 14-01-2021 **Online:** 02-03-2021

MYMV disease is caused by a *Begomovirus* that belongs to the family Geminiviridae and order Geplafuvirales which has become a major threat to the pulse crop production in India. The major symptom of this disease is

the yellow colour mottling on the leaves and later turn the whole leaf to yellow colour under severe conditions the total foliage appears yellow causing the major photosynthetic losses. During the early stages of crop growth this disease leads to malformations in the growing tips and younger leaves affecting growth of the plant.

Several approaches were being adopted for the control of MYMV disease with in the field conditions such as use of insecticide sprays for the control of vectors, but it is near impossible to achieve full control of the disease. Development of resistant varieties is the most economical and effective solution for the control of disease, that is why there is a need to develop greengram varieties of high resistance to MYMV. The present field experiment was conducted to study the physiological and biochemical basis of resistance to MYMV disease in greengram varieties including both resistant and susceptible varieties.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* 2017-18 and 2018-19 at RARS Lam Guntur in a randomized block design with eight greengram genotypes and replicated thrice under receding soil moisture condition. Experiment was conducted using eight genotypes of greengram (WGG 42, Pusa Vishal, LGG 607, LGG 630, LGG 601, LGG 610, LGG 460 and LGG 450) obtained from RARS Lam Guntur. The plot size was 4 rows with 4 meter length and sown with a spacing of 30×10 cm. The estimation of sugars, phenols, tannins, trichome density and SCMR was done at vegetative and reproductive stages of crop growth. The SCMR value was measured using Minolta SPAD-502 Chlorophyll meter. The seed yield was recorded at maturity. The experimental data was statistically analyzed using OPSTAT.

Trichome density

The trifoliate leaves from ten randomly selected plants of a plot were brought from the field and were cut into leaf discs of 1 cm diameter. These discs were observed under a stereo microscope to count the number of hairs present on the leaf disc and the average value of the trichome density was calculated as cm^2 leaf area.

SPAD Chlorophyll meter reading (SCMR)

The SPAD meter reading was recorded from ten randomly selected plants within the plot. The most exposed leaf was preferred to record the SCMR value.

Total sugars (mg g^{-1} FW)

Total sugar content was estimated using anthrone reagent method (Hedge and Hofreiter, 1962). Fresh leaf sample of 0.25 g was ground in 5 mL of 70% hot ethanol and centrifuged at 5000 rpm for 15 min. Then the supernatant was discarded and the pellet was air dried. After air drying 5 ml of anthrone reagent (2 g of anthrone in 1 L 10:4 v/v Conc. H_2SO_4) was added to the pellet and the tubes were kept in ice bath at 4°C for 10 min and immediately the tubes were transferred to water bath at 80°C for 30 min. Later, the tubes were cooled to room temperature and the absorbance was read at 620 nm. A series of standards were prepared using fructose (1 mg per 10 ml) stock solution.

Total sugars (mg/g FW of leaf) =

$$\frac{\text{Concentration} \times \text{Qty of extract prepared}}{1000 \times \text{Weight of the sample}}$$

Phenols (mg g^{-1} FW)

Leaf phenol content was estimated (Malik and Singh, 1980) using folin's reagent in which 0.25 g of fresh leaf was ground in 5 ml of 80% ethanol and kept it for 1 hour. 1 ml of aliquot was collected and 2 ml of 1 M Sodium Carbonate (10.6 g in 100 ml distilled water) was added. Later, 1 ml of folin reagent (1:9 v/v with water) was added and the tubes were kept in water bath for 20 min at 70°C. The absorbance was measured at 765 nm. Standard stock was prepared by using 0.5 g gallic acid in 10 mL ethanol and 90 mL of water and series of different concentrations as standards were made.

Total phenols (mg/g fresh wt of leaf) =

$$\frac{\text{Concentration} \times \text{Qty of extract prepared}}{1000 \times \text{Weight of the sample}}$$

Tannins (mg g^{-1} DW)

A powdered dry leaf sample of 0.5g was taken in test tube and 7.5 ml of water was added to it. The test tubes were kept in boiling water bath of 100°C for 30 min. The contents were centrifuged at 10,000 rpm for 20 min and the supernatant was collected. The volume was made to 10 ml with water. The extract obtained was used for assay with Folin-Denis' reagent by adding 0.5 ml of the reagent to the 0.1 ml of plant extract and also added 1 ml of 35% sodium carbonate solution and shaken well kept at room temperature for 30 min to take the readings at 700 nm. A set of standard solutions were made of tannic acid (10, 20, 30, 40, 50 µg ml^{-1}) and the tannins content of the samples was expressed in mg g^{-1} dry weight of the sample (Sadasivam and Manickam,1992).

Disease score

It is natural disease appearing during crop season. The plot wise symptoms on the plants were observed and per cent incidence of the disease was calculated by dividing the number of infected plants by total plant population of the plot and multiplied by hundred. Disease scoring was given based on formula given by Alice and Nadarajan (2007)

RESULTS AND DISCUSSION

Sugars

The sugar content of the leaves of greengram varieties was estimated by anthrone method and the values are given in Table 1. A significant difference was observed for total sugars among the varieties at vegetative and reproductive stages during both *rabi* 2017-18 and 2018-19. At vegetative stage during rabi 2017-18, higher total sugar content was recorded in the variety LGG 450 (45.27 mg g^{-1} FW) followed by LGG 460 (43.65 mg g^{-1} FW) and LGG 601 (41.21 mg g^{-1} FW) which

Disease scoring scale (0-9) for MYMV based on percentage disease incidence (PDI).

Disease scale	Per cent infection	Category	Reaction group
1	No plants showing any symptoms	Free	
2	Small specks of 0.1 to 5% leaf area spread	Highly resistant	HR
3	Mottling of leaves of 5.1-10 % leaf area	Resistant	R
4	Yellow mottling covering 10.1-15% leaf area	Moderately resistant	MR
5	Yellow mottling and discolouration of 15.1-20% leaf area	Moderately susceptible	MS
6	Yellow colouration of 20.1-30% leaves and pods	Susceptible	S
7	Pronounced yellow mottling and discolouration of 30.1-50% of foliage	Susceptible	S
8	Severe yellow discolouration of leaves 50.1-75% of foliage, stunted growth and reduction in pod size	Highly susceptible	HS
9	Severe yellowing of leaves covering above 75% foliage, stunting of plants and no pod formation	Highly susceptible	HS

are at par with each other and the lowest sugar content was recorded in the variety LGG 630 (35.40 mg g^{-1} FW) preceded by WGG 42 (36.13 mg g^{-1} FW). At reproductive stage during *rabi* 2017-18, highest sugar content was recorded in variety LGG 450 (34.42 mg g^{-1} FW) followed by LGG 460 (33.53 mg g^{-1} FW) which are significantly higher than the other varieties and are at par with each other followed by LGG 601 (30.58 mg g^{-1} FW) and are at par with each other and the lowest sugar content was recorded in the variety LGG 630 (25.55 mg g^{-1} FW) preceded by WGG 42 (26.25 mg g^{-1} FW).

At vegetative stage during *rabi* 2018-19 higher sugar content was recorded in the varieties LGG 450 (47.32 mg g^{-1} FW) followed by LGG 460 (45.70 mg g^{-1} FW) and are at par with one another and the lowest sugar content was recorded in the variety LGG 630 (37.45 mg g^{-1} FW) preceded by WGG 42 (38.18 mg g^{-1} FW). At reproductive stage the leaf sugar content of the greengram varieties followed the trend that was observed earlier with higher sugar content in the variety LGG 450 (36.47 mg g^{-1} FW) and the lower sugar content was record in the variety LGG 630 (27.60 mg g^{-1} FW).

The leaf total sugar content decreased from vegetative stage to reproductive stage in all the greengram varieties tested. The total sugar content of the plants contributes as a nutritious diet to whitefly, insect vector that transmits the MYMV disease. From the correlation studies it is evident that the total sugar content of the plants has a significant positive association with the whitefly population (Table 8). The increased total sugar content after MYMV infection in the greengram varieties increased the whiteflies populations especially on susceptible varieties. The increased whitefly populations increase the disease incidence on the susceptible varieties. The MYMV disease infection has reduced the total sugar content in all the varieties and the reduction was higher in susceptible varieties (Ghuge *et al*., 2018). Similar results were previously reported by Narasimhulu *et al*. (2014) in greengram varieties.

Phenolic content

A significant variation was observed among the varieties tested for leaf phenolic content at vegetative and reproductive stages during *rabi* 2017-18 and 2018-19 (Table 2). The leaf phenolic content at reproductive stage during rabi 2017-18 was observed to be higher in the variety LGG 630 (25.78 mg g^{-1} FW) followed by WGG 42 (25.18 mg g^{-1} FW) and PusaVishal (23.32 mg g^{-1} FW) which are in line with one another. The lowest phenolic content was recorded in the variety LGG 450 (15.37 mg g^{-1} FW). At vegetative stage during *rabi* 2017-18 highest phenolic content was recorded

Table 1: Total sugars content of greengram varieties as affected by MYMV disease during *Rabi* 2017-18 and 2018-19.

Varieties	Total sugars (mg g^{-1}FW)			
	2017-2018		2018-2019	
	30 DAS	50 DAS	30 DAS	50 DAS
WGG 42	36.13	26.25	38.18	28.30
PusaVishal	40.38	30.12	42.43	32.17
LGG 607	37.13	26.87	39.18	28.92
LGG 630	35.40	25.55	37.45	27.60
LGG 601	41.21	30.58	43.26	32.63
LGG 610	38.13	27.80	40.18	29.85
LGG 460	43.65	33.53	45.70	35.58
LGG 450	45.27	34.42	47.32	36.47
CD at 5%	4.5	4.1	3.5	3.6
CV%	12.9	13.5	13.9	14.5

Table 2: Phenolic content of greengram varieties as affected by MYMV disease during *Rabi* 2017-18 and 2018-19.

Varieties	Phenols (mg/g FW of leaf)			
	2017-2018		2018-2019	
	30 DAS	50 DAS	30 DAS	50 DAS
WGG 42	20.45	25.18	21.50	26.23
PusaVishal	17.45	23.32	18.49	24.37
LGG 607	18.40	20.29	19.45	21.34
LGG 630	21.40	25.78	20.44	26.83
LGG 601	15.18	18.15	16.23	19.20
LGG 610	18.30	21.19	19.35	22.24
LGG 460	14.12	17.54	15.17	18.59
LGG 450	12.09	15.37	13.14	16.43
CD at 5%	4.1	3.82	3.3	3.32
CV%	12.5	11.50	12.57	12.50

in the variety LGG 630 (21.40 mg g^{-1}FW) followed by WGG42 (20.45 mg g^{-1} FW) and LGG 607 (18.40 mg g^{-1} FW). At reproductive stage during *rabi* 2018-19, higher phenolic content was recorded in the variety LGG 630 (26.83 mg g^{-1} FW) followed by WGG 42 (26.23 mg g^{-1} FW) both are on a par with each other and lowest phenolic content was recorded in the variety LGG 450 (16.43 mg g^{-1} FW). At vegetative stage during *rabi* 2018-19 the highest phenolic content was recorded in the variety WGG 42 (21.50 mg g^{-1} FW) followed by LGG 630 (20.44 mg g^{-1} FW) and the lowest was recorded in the variety LGG 460 (13.14 mg g^{-1} FW).

A significantly higher phenolic content was observed in the leaves of varieties that showed lower disease incidence under field conditions indicating the importance of phenolic content for MYMV resistance. The phenolic compounds have attributed to the resistance of host plant towards the whitefly as the toxic nature of phenol causes damage to the insect. Further, phenolic compounds are capable of increasing the anti-oxidant enzyme activities such as phenyl alanine lyases and trigger the antioxidant activities of catalase and peroxidase. Similar results were obtained in greengram varieties by Mantesh *et al*. (2020) and Basavaraj *et al*. (2019) in soybean by Singh *et al*. (2019).

Tannins

The tannin content of the dried leaf samples was measured at vegetative and reproductive stages during both *rabi* 2017-18 and 2018-19 and the mean values were tabulated in Table 3 in mg g^{-1} DW and a significant variation was observed among the varieties tested. At reproductive stage during *rabi* 2017-18 the higher tannin content was recorded in the variety LGG 630 (0.055 mg g^{-1} DW) followed by WGG 42 (0.053 mg g^{-1} DW) and the lowest tannin content was recorded in the variety LGG 450 (0.035 mg g^{-1} DW). At 30 DAS stage during 2017-18, highest tannin content was recorded in the variety LGG 630 (0.040 mg g^{-1}DW) followed by WGG 42 (0.038 mg g^{-1} DW) and the lowest was recorded in the variety LGG 450 (0.022 mg g^{-1} DW).

During *rabi* 2018-19 at reproductive stage the higher tannins content was recorded in the variety LGG 630 (0.053 mg g^{-1} DW) of the leaf followed by WGG 42 (0.051 mg g^{-1} DW) and the lower tannins content was recorded in the variety LGG 450 (0.033 mg g^{-1} DW). At vegetative stage during *rabi* 2018-19 the higher tannins content was recorded in the variety LGG 630 (0.038 mg g^{-1} DW) followed by WGG 42 (0.036 mg g^{-1} DW) and the lower tannins content was recorded in the variety LGG 450 (0.020 mg g^{-1} DW).

The tannins are a group of phenolic compounds which are known for their astringent nature and protect the plant from insect pests through antibiosis. The higher tannins content values are recorded in the varieties with lower disease score. The tannins content has significantly affected the vector population which has reduced the per cent disease incidence. The tannins production along with the pigmentation has influence on host plant resistance (Davies, 2004). A significant higher tannins and flavonoids content were observed in the MYMV resistant varieties of blackgram (Taggar *et al*., 2014).

Trichome density

The trichome density of the ten randomly selected most exposed leaves from each plot were taken and the average number of trichomes was calculated per cm^2 and the values were enumerated in Table 4. The trichome density values indicate the average number of trichomes per cm^2 of the leaf lamina. The pubescence of the leaf plays an important role in repelling the pests.

At vegetative stage during *rabi* 2017-18 the higher trichome density was recorded in the variety LGG 630 (162/cm^2 of leaf area) (Plate 1A) followed by WGG 42 (149/cm^2 of leaf area) and the lower trichome density was observed in the variety LGG 450 (95/cm^2 of leaf area). At reproductive stage during *rabi* 2017-18 the highest trichome density was recorded in the variety LGG 630 (153/cm^2 of leaf area) followed by WGG 42 (142/cm^2 leaf area) and the lowest was recorded in the variety LGG 450 (77/cm^2 of leaf area). At vegetative stage during *rabi* 2018-19 the highest trichome density was recorded in the variety LGG 630 (160/cm^2 of leaf area) followed by WGG 42 (147/cm^2 of leaf area) and the lowest trichome density was observed in the variety LGG 460 (93/cm^2 of leaf area) (Plate 1B). At reproductive stage during *rabi* 2018-19 the highest trichome density was

Table 3: Tannin content of greengram varieties as affected by MYMV disease during *Rabi* 2017-18 and 2018-19.

Varieties	Tannins content (mg g^{-1}DW)			
	2017-2018		2018-2019	
	30 DAS	50 DAS	30 DAS	50 DAS
WGG 42	0.038	0.053	0.036	0.051
PusaVishal	0.030	0.046	0.028	0.044
LGG 607	0.035	0.050	0.033	0.048
LGG 630	0.040	0.055	0.038	0.053
LGG 601	0.028	0.043	0.026	0.041
LGG 610	0.032	0.043	0.030	0.041
LGG 460	0.025	0.038	0.023	0.036
LGG 450	0.022	0.035	0.020	0.033
CD at 5%	0.009	0.009	0.008	0.008
CV%	17.1	2.78	12.1	8.78

Table 4: Trichome densities of greengram varieties as affected by MYMV disease during *Rabi* 2017-18 and 2018-19.

Varieties	Trichome density (Number/cm^2 Leaf area)			
	2017-2018		2018-2019	
	30 DAS	50 DAS	30 DAS	50 DAS
WGG 42	149	142	147	140
PusaVishal	124	118	122	116
LGG 607	144	132	142	130
LGG 630	162	153	160	151
LGG 601	120	115	118	113
LGG 610	135	135	133	133
LGG 460	101	96	100	94
LGG 450	95	77	93	75
CD at 5%	18.12	14.9	13.12	12.9
CV%	8.1	7.1	8.17	9.1

recorded in the variety LGG 630 (151/cm^2 of leaf area) followed by WGG 42 (140/cm^2 leaf area) and the lowest was recorded in the variety LGG 460 (75/cm^2 of leaf area).

The trichome density showed a significant effect on whitefly population in greengram varieties. Higher trichome density reduced the feeding preference of the whitefly on plants and reduced the per cent disease incidence and score. The resistant varieties showed higher values of trichome density. Mantesh *et al*. (2020) observed similar results in greengram varieties against whitefly infestation. A reduced whitefly population was observed in the blackgram varieties with higher trichome density (Taggar and Gill, 2012).

SCMR (SPAD Chlorophyll meter reading)

At vegetative stage during *rabi* 2017-18 the higher SCMR value (Table 5) was recorded in the variety LGG 630 (52.29) followed by WGG 42 (50.50) and the lower SCMR was observed in the variety LGG 450 (38.12). At reproductive stage during *rabi* 2017-18 the higher SCMR value was recorded in the variety LGG 630 (56.67) followed by WGG 42 (53.54) and the lower value was recorded in the variety LGG 450 (43.07). At vegetative stage during *rabi* 2018-19 the higher SCMR value was recorded in the variety LGG 630 (54.29) followed by WGG 42 (52.50) and the lower value was observed in the variety LGG 460 (35.12). At reproductive stage during *rabi* 2018-19 the higher SCMR value was recorded in the variety LGG 630 (58.67) followed by WGG 42 (55.54) and the lower value was recorded in the variety LGG 450 (36.07).

The MYMV disease infection reduced the chlorophyll contents of the plants. The varieties with higher SCMR values were observed having darker foliage which in turn reduces the whitefly population in those varieties. The reduction in chlorophyll was higher in the susceptible varieties which has reduced the SCMR value significantly. The total chlorophyll content was higher in resistant varieties of greengram (Mantesh *et al*., 2020).

Disease score

The disease score values recorded at reproductive stage in all the varieties showed observable variation among the varieties (Table 6). The varieties WGG 42 and LGG 630 showed a score of '2' during both *rabi* 2017-18 and 2018-19 which indicates highly resistant type. The varieties PusaVishal, LGG 607 and LGG 610 showed a score of '3' during both *rabi* 2017-18 and 2018-19 indicating resistant type. The variety LGG 601 recorded a score of '5' during both *rabi* 2017-18 and 2018-19 indicating moderately susceptible type. The variety LGG 460 recorded a score of '6' during *rabi* 2017-18 and 2018-19 which showed susceptible nature of the variety. The variety LGG 450 showed a score of '8' during both *rabi* 2017-18 and 2018-19 showing highly susceptible nature. The score given by Alice and Natarajan, (2007) was previously used by Raj *et al*. (2019) in screening greengram varieties and Gopi *et al*. (2018) in the screening of blackgram varieties.

Yield

During *rabi* 2017-18 the highest seed yield (Table 7) was recorded in the variety LGG 630 (1076 kg ha^{-1}) followed by WGG 42 (980 kg ha^{-1}) and the lowest seed yield was recorded in the variety LGG 450 (650 kg ha^{-1}). During *rabi* 2018-19 the highest seed yield was recorded in the variety LGG 630 (1122 kg ha^{-1}) followed by WGG 42 (1030 kg ha^{-1}) and the lower seed yield was recorded in the variety LGG 460 (655 kg ha^{-1}). The disease incidence has significantly reduced the yield of the susceptible varieties and the yields of resistant varieties stayed unaffected.

Table 5: SCMR values of greengram varieties as affected by MYMV disease during *Rabi* 2017-18 and 2018-19.

Varieties	SCMR			
	2017-2018		2018-2019	
	30 DAS	50 DAS	30 DAS	50 DAS
WGG 42	50.50	53.54	52.50	55.54
PusaVishal	44.46	47.51	46.46	49.51
LGG 607	47.11	51.07	49.11	53.07
LGG 630	52.29	56.67	54.29	58.67
LGG 601	41.75	45.23	43.75	47.23
LGG 610	46.52	50.07	48.52	52.07
LGG 460	40.03	43.34	38.03	39.34
LGG 450	38.12	43.07	35.12	36.07
CD at 5%	5.12	4.5	4.52	4.2
Cv%	22.8	22.0	20.4	22.0

Table 6: MYMV disease score of greengram varieties asaffected by MYMV disease during *Rabi* 2017-18 and 2018-19.

Varieties	Disease score (0-9)		Category	Reaction group
	2017-2018	2018-2019		
WGG 42	2	2	Highly resistant	HR
PusaVishal	3	3	Resistant	R
LGG 607	3	3	Resistant	R
LGG 630	2	2	Highly resistant	HR
LGG 601	5	5	Moderately susceptible	MS
LGG 610	3	3	Resistant	R
LGG 460	6	6	Susceptible	S
LGG 450	8	8	Highly susceptible	HS

Table 7: Seed yield of greengram varieties asaffected by MYMV disease during *Rabi* 2017-18 and 2018-19.

Varieties	Seed yield (Kg/ha)	
	2017-2018	2018-2019
WGG42	980	1030
PusaVishal	850	900
LGG 607	801	850
LGG 630	1076	1122
LGG 601	810	860
LGG 610	870	922
LGG 460	740	756
LGG 450	650	655
CD at 5%	182	157
CV%	12.3	12.3

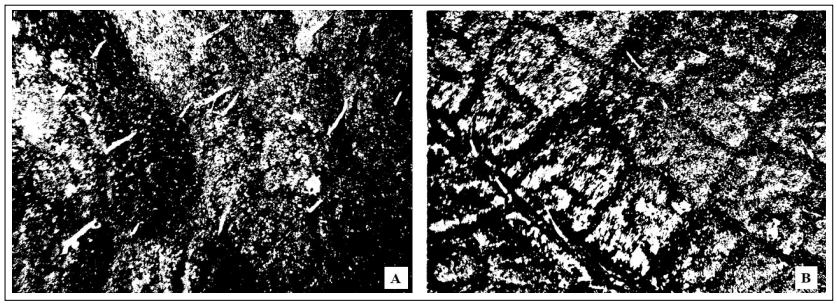

Plate 1: Variation in trichome density of varieties LGG 630 (A) and LGG 460 (B) at 4x optical zoom.

Table 8: Correlation of the traits observed with disease score in greengram varieties.

	Disease score
Total sugars content	0.915**
Phenols content	-0.941**
Tannins content	-0.789*
Trichome density	-0.926**
SCMR	-0.928**
Yield	-0.921**

Correlations

The correlation studies indicated that the disease score showed a highly significant negative correlation with phenols, tannins content, trichome density, SCMR and yield and a highly significant positive correlation with total sugars content (Table 8). Mantesh *et al*. (2020) observed significant negative correlations between trichome density, phenols and chlorophyll contents among the greengram varieties.

CONCLUSION

From these results it can be inferred that higher phenols, tannins content and trichome density and less sugars content traits contributed MYMV resistance in LGG 630 and WGG 42 of greengram. The genotypes WGG 42 and LGG 630 were grouped under highly resistant category with higher phenol and tannin content and higher trichome density. The genotypes Pusa Vishal, LGG 607 and LGG 610 were categorised under resistant group. The varieties LGG 460 and LGG 450 were grouped under susceptible and highly susceptible categories respectively with lower phenol and tannin content and lower trichome density.

REFERENCES

Alice, D. and Nadarajan, N. (2007). Screening Technique and Assessment Method for Disease Resistance. Department of Pulses, Tamil Nadu Agricultural University, Coimbatore.

Basavaraj, S., Padmaja, A.S., Nagaraju, N. and Ramesh, S. (2019). Identification of stable sources of resistance to mungbean yellow mosaic virus (MYMV) disease in mungbean [*Vigna radiata* (L.) Wilczek]. Plant Genetic Resources. 17(4): 362-370.

Davies, K.M. (2004). Important Rare Plant Pigments. In: Plant Pigments and their Manipulation. [K.M. Davies (ed.)], Annual Plant Reviews. Blackwell publishing, Oxford. 14: 214-247.

Ghuge, A.S., Gupta Vinod, R., Patel Sajeda, E. and Zade Samir, B. (2018). Biochemical changes induced by Mungbean yellow mosaic virus (MYMV) in mungbean [*Vigna radiata* (L.) Wilczek]. Indian Journal of Chemical Studies. 6(5): 2156-2159.

Gopi, P., Satyanarayana, A., Krishna, A.R. and Rao, K.R.S. (2018). Genetics of resistance to yellow mosaic virus (YMV) disease in blackgram [*Vigna mungo* (L.) Hepper]. Research on Crops. 19(2): 285-288.

Hedge, J.E. and Hofreiter, B.T. (1962). Carbohydrate Chemistry 17. Whistler, R.L. and Be Miller, J. N., Eds., Academic Press, New York.

Malik, C.P. and Singh, M.B. (1980). Plant Enzymology and Histo-enzymology. Kalyani Publishers, New Delhi.

Mantesh, M., Venkatesh and Pankaja, N.S. (2020). The studies on the morphological variability and biochemical changes induced by mungbean yellow mosaic virus (MYMV) in mungbean [*Vigna radiata* (L.) Wilczek]. Indian Phytopathology. 73(3): 543-553.

Narasimhulu, R., Naidu, N.V., Reddy, K.H.P., Rajan, C.P.D. and Naidu, G.M. (2014). Association analysis among yield attributes in greengram [*Vigna radiata* (L.) Wilczek]. Bioinflolet. 11(4a): 1021-1025.

Raj, K.R., Baisakh, B., Tripathy, S.K., Lenka, D., Pradhan, B., Mishra, M.K., Salini, K. and Mohanty, M.R. (2019). Screening for mungbean yellow mosaic virus resistance in green gram [*Vigna radiata* (L.) Wilczek]. International Journal of Current Microbiology and Applied Sciences. 8(10): 666-670.

Sadasivam, S. and Manickam, A. (1992). Biochemical Methods for Agricultural Sciences. Wiley Eastern Ltd., New Delhi.

Singh, C.M., Singh, P., Pratap, A., Pandey, R., Purwar, S., Douglas, C.A., Baek, K.H. and Mishra, A.K. (2019). Breeding for enhancing Legumovirus resistance in mungbean: current understanding and future directions. Agronomy. 9(10): 622.

Taggar, G.K. and Gill, R.S. (2012). Preference of whitefly, *Bemisia tabaci*, towards black gram genotypes: Role of morphological leaf characteristics. Phytoparasitica. 40(5): 461-474.

Taggar, G.K., Gill, R.S., Gupta, A.K. and Singh, S. (2014). Induced changes in the antioxidative compounds of *Vigna mungo* genotypes due to infestation by *Bemisia tabaci* (Genna dius). Journal of environmental Biology. 35(6): 1037-1045.

Yadav, M.S., Brar, K.S. (2010). Assessment of yield losses due to mungbean yellow mosaic India virus and evaluation of mungbean genotypes for resistance in South West Punjab. Indian Phytopathology. 63(3): 318-320.