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Biochemical changes induced by *Mungbean yellow mosaic virus* (MYMV) in mungbean [*Vigna radiata* (L.) Wilczek]

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Abstract
In present investigation biochemical changes in mungbean induced by the Mungbean yellow mosaic virus were investigated. In biochemical parameters, protein, Total phenol and total sugar content was studied. The biochemical contents in healthy plants were analyzed at different stages i.e. 15 DAS and at 30 DAS in resistant (HUM 6, and IPM 312-9), moderately resistant (SML 1811 and AKM 12-06) and susceptible (AKM 12-14 and AKM 10-11) was also compared with infected plants of same genotypes. The protein content was more in healthy plants of resistant genotypes than moderately resistant followed by susceptible at 15 and 30 DAS. The content was found increased in infected plants than healthy plants of resistant followed by moderately resistant and susceptible at 30 DAS. The total phenol content was also maximum in resistant followed by moderately resistant and susceptible. When analyzed at 30 DAS from healthy plants of these genotypes further the content was increased in infected plants than healthy plants of resistant followed by moderately resistant and susceptible. Decreased total sugar content was recorded in resistant genotypes than moderately resistant followed by susceptible genotypes at 15 and 30 DAS.

Keywords: mungbean yellow mosaic virus, vigna radiate, biochemical parameters

Introduction
Green gram (*Vigna radiata* (L.) Wilczek) commonly known as mungbean or mung is very ancient annual crop in Indian farming. It is an excellent source of high quality protein with easy digestibility hence adviced to patients also. Mungbean yellow mosaic virus is a destructive virus that causes severe yield losses of mungbean crops. MYMV incidence is as high as 100 per cent in farmer's field in the Indian subcontinent, often resulting in considerable yield losses (Green *et al*., 2002) [11]. Mungbean yellow mosaic virus belongs to family Geminiviridae and genus Begomovirus. It also infects other legume crops, including Urdbean, Soybean and Cowpea (Dhingra and Chenulu, 1985) [8]. This disease causes severe destruction of legume crops in Pakistan, Srilanka, Bangladesh and India (Bakar, 1981; Biswas *et al*., 2008) [1, 3]. MYMD is responsible for causing more than US$300 million loss every year in different leguminous crops. The virus particles are isometric, paired, 18-30 nm in size and have single stranded DNA. The virus particles are confined to phloem associated elements in infected plants.

Whitefly is the only vector reported by several scientists for the natural transmission of virus in different plants. The whitefly nymphs obtain the virus from diseased leaves. Influence of whitefly population on MYMV has been already reported by Nadeem *et al*., (2006). Therefore, use of disease resistant crop varieties is regarded as an economical and durable method of controlling viral disease. A good deal of research have been directed towards screening of mungbean germplasm against mungbean yellow mosaic disease for identification of resistant sources under diverse environmental conditions.

Material and Methods
Two entries each from resistant, moderately resistance and susceptible reaction screened during summer 2017 were selected for estimation of biochemical parameters. For that the selected entries were planted during Kharif season of 2017 after confirming its reaction during. Biochemical constituents such as protein, total sugar, and total phenol of different varieties (susceptible, moderately resistant and resistant) were estimated using

method given by scientists – Protein by Lowry (1951) [12], Total sugar by Dubois *et al*.(1956) [9] and Total phenol - Bray and Thorpe (1954). The biochemical constituent were estimated from healthy plants of selected susceptible, moderately resistant and resistant genotypes at 15 and 30 DAS. For this purpose fresh leaf sample were collected from randomly selected 5 plants of each entry representing top, middle and bottom leaves.

Result and Discussion

1. Protein

a) Protein content of healthy plants during kharif 2017

Protein content of genotypes varied from 0.19 to 0.27 mg/g fresh weight of the leaves. (Table 1) The minimum (0.19 mg/g) was being recorded in susceptible AKM 12-14 whereas maximum (0.27 mg/g) was observed in resistant HUM 6 at 15 DAS. Statistically significant differences were observed in protein content of genotypes exhibiting different reaction to YMD. It was found that the protein content was highest in resistant genotypes (0.27 and 0.26 mg/g in HUM 6 and IPM 312-9 respectively) followed by moderately resistant (0.25 and 0.24 mg/g in AKM 12-06 and SML 1811 respectively) and susceptible (0.22 and 0.19 mg/g in AKM 10-11 and AKM 12-14 respectively).

Similar trend was observed at 30 DAS also where the protein content ranged from 0.23 to 0.29 mg/g minimum being in susceptible AKM 12-14 and maximum in resistant IPM 312-9. Although the protein content was more in resistant followed by moderately resistant and susceptible and went on increasing from 15 DAS to 30 DAS in all the genotypes, the per cent disease incidence had not shown any definite behaviour with protein content which discourages correlating protein content with the reaction of genotype against YMD for the want of literature as earlier workers only mentioned changes in protein content in infected plant compared to healthy one.

b) Protein content of healthy and infected plants during Summer 2018.

Increased protein content was observed in infected leaves compared to healthy in all genotypes during both period of observation i.e. 15 and 30 DAS. At 15 DAS the protein content recorded in infected susceptible genotypes (AKM 12-14 and AKM 10-11) were 0.23 and 0.25 mg/g fresh weight compared to 0.22 and 0.24 mg/g fresh weight in healthy leaves of these genotypes. During this period of observation the protein content was increased by 0.01 mg/g fresh weight in susceptible, 0.02 to 0.04 mg/g in moderately resistant and 0.01 to 0.02 mg/g fresh weight in resistant genotypes. The trend of increased protein content in infected leaves compared to healthy was also observed at 30 DAS, however at these period increase was slightly more compared to first observation (15 DAS). At 30 DAS the content was 0.28 mg/g fresh weight in infected susceptible genotypes (both AKM 12-14 and AKM 10-11) compared to 0.25 and 0.26 mg/g in healthy leaves of these genotypes. (table 2). The infected susceptible, moderately resistant and resistant genotypes exhibited increased protein content by 0.02 to 0.03 mg/g, 0.01 to 0.05 mg/g and 0.03 to 0.04 mg/g fresh weight over healthy leaves of susceptible, moderately resistant and resistant genotypes.

2. Total phenol

a) Phenol content of healthy plants during kharif 2017

Phenol content varied significantly in genotypes exhibiting different reaction to YMD. Minimum phenol content (0.28 mg/g) was recorded in both susceptible AKM 12-14 and AKM 10-11 whereas maximum (0.46 mg/g) was observed in resistant IPM 312-9 at 15 DAS. It was found that the resistant genotypes contained more phenol than moderately resistant and susceptible.

Similar trend was observed at 30 DAS also where the phenol content ranged from 0.32 to 0.48 mg/g. Susceptible AKM 10-11 and AKM 12-14 showed 0.32 and 0.33 mg/g phenol, whereas resistant IPM 312-9 and HUM 6 each contained 0.48 mg/g phenol. The content was increased from 15 DAS to 30 DAS in all the genotypes. But the increase in PDI from 15 DAS to 30 DAS was less compared to increase during subsequent period of observations which suggest the role of phenol in governing the reaction of genotypes either by virus or by the vector. Probably the preference of vector to the genotype might be favoured by the phenol content of the genotypes.

b) Phenol content of healthy and infected plants during Summer 2018.

Phenol content was increased in infected leaves compared to healthy in all genotypes during both period of observation i.e.15 and 30 DAS (Table 4). At 15 DAS the phenol content recorded in infected susceptible genotypes (AKM 12-14 and AKM 10-11) were 0.34 and 0.37 mg/g fresh weight of leaves compared to 0.32 and 0.34 mg/g fresh weight in healthy leaves of these genotypes. During this period of observation the phenol content was increased by 0.02 and 0.03 mg/g fresh weight in susceptible, 0.05 mg/g in moderately resistant and 0.06 and 0.07 mg/g fresh weight in resistant genotypes. The increase in phenol content in infected sample compared to healthy of same genotypes was more in resistant followed by moderately resistant and susceptible. The trend of increased phenol content in infected leaves compared to healthy was also observed at 30 DAS, where the content was 0.40 and 0.43 mg/g fresh weight in infected susceptible genotypes (AKM 12-14 and AKM 10-11) compared to 0.36 and 0.40 mg/g in healthy leaves of these genotypes. At this period increase was more or less same as observed in first observation i.e. 15 DAS.

The infected susceptible, moderately resistant and resistant genotypes exhibited increased phenol content by 0.03 to 0.04 mg/g, 0.04 mg/g and 0.06 to 0.07 mg/g fresh weight over healthy leaves of susceptible, moderately resistant and resistant genotypes.

3. Total sugar

a) Total sugar content of healthy plants during kharif 2017

Total sugar content of different genotypes varied from 2.70 to 3.57 mg/g fresh weight of the leaves at 15 DAS and 3.03 to 3.97 mg/g fresh wt. at 30 DAS (table 5). The minimum of 2.70 mg/g was recorded in susceptible AKM 12-14 whereas maximum of 3.57 mg/g was observed in resistant IPM 312-9 at 15 DAS. Significant differences were observed in total sugar content of genotypes exhibiting different reaction to YMD during both the observations. It was found that total sugar content was maximum in resistant genotypes (3.57 and 3.40 mg/g in IPM 312-9 and HUM 6 respectively) at 15 DAS followed by moderately resistant (3.30 and 3.07 mg/g in AKM 12-06 and SML 1811 respectively) and susceptible (2.73 and 2.70 mg/g in AKM 10-11 and AKM 12-14 respectively)

Similar trend was observed at 30 DAS also where the minimum sugar content was recorded in susceptible AKM 12-14 (3.03 mg/g) and maximum (3.97 mg/g) in resistant IPM 312-9. In general the content of total sugar was more in resistant followed by moderately resistant and susceptible genotypes and was more at 30 DAS than of 15 DAS in all the genotypes.

b) Total sugar content of healthy and infected plants during Summer 2018.

Decreased total sugar content was observed in infected leaves compared to healthy in all genotypes during both period of observation i.e.15 and 30 DAS (Table 6). At 15 DAS total sugar content recorded in infected susceptible genotypes (AKM 12-14 and AKM 10-11) were 2.98 and 3.01 mg/g fresh weight compared to 3.16 and 3.28 mg/g fresh weight in healthy leaves of these genotypes. Total sugar content was 2.86 and 3.03 mg/g in infected leaves of moderately resistant AKM 12-06 and SML 1811 respectively compared to 3.58 and 3.50 mg/g in healthy leaves of same genotypes. The decrease in sugar content was by 0.18 to 0.27 mg/g fresh weight in susceptible, 0.47 to 0.72 mg/g in moderately resistant and 0.49 to 0.68 mg/g fresh weight in resistant genotypes. The trend of decreased total sugar content in infected leaves compared to healthy was also observed at 30 DAS, however at this period the decrease in sugar content was less in infected samples than healthy compared to first observation (15 DAS). At 30 DAS the content was 3.11 and 3.21 mg/g fresh weight in infected susceptible genotypes (AKM 12-14 and AKM 10-11) compared to 3.37 and 3.45 mg/g in healthy leaves of these genotypes, further it was 3.11 and 3.07 mg/g in infected samples of moderately resistant (SML 1811 and AKM 12-06) compared to 3.56 and 3.43 mg/g in healthy leaves of these genotypes and 3.13 and 3.16 mg/g in infected sample of resistant (HUM 6 and IPM 312-9 respectively) compared to 3.86 and 3.91 mg/g in healthy leaves of these genotypes.

The infected susceptible, moderately resistant and resistant genotypes exhibited decreased total sugar content by 0.24 to 0.26 mg/g, 0.36 to 0.45 mg/g and 0.73 to 0.75 mg/g fresh weight over healthy leaves of susceptible, moderately resistant and resistant genotypes.

Table 1: Protein content (mg/g fresh wt.) in healthy plants of Mungbean at different stages during Kharif 2017.

Sr. No.	Genotypes	Protein content (mg/g)	
		15 DAS	30 DAS
1	AKM 12-14 (S)	0.19	0.23
2	AKM 10 11 (S)	0.22	0.24
3	SML 1811 (MR)	0.24	0.25
4	AKM 12 06 (MR)	0.25	0.27
5	HUM 6 (R)	0.27	0.27
6	IPM 312-9 (R)	0.26	0.29
	F test	Sig	Sig
	SE (m±)	0.01	0.01
	CD, P = 0.01	0.03	0.03

Table 2: Protein content (mg/g fresh wt.) in healthy and YMV infected plants of mungbean during summer 2018

Sr. No.	Genotypes	Protein content (mg/g)			
		15 DAS		30 DAS	
		Healthy	Infected	Healthy	Infected
1	AKM 12-14 (S)	0.22	0.23	0.25	0.28
2	AKM 10 11 (S)	0.24	0.25	0.26	0.28
3	SML 1811 (MR)	0.22	0.26	0.25	0.30
4	AKM 12 06 (MR)	0.24	0.26	0.28	0.29
5	HUM 6 (R)	0.27	0.28	0.3	0.33
6	IPM 312-9 (R)	0.28	0.3	0.31	0.35
	F test	Sig	Sig	Sig	Sig
	SE (m±)	0.01	0.01	0.01	0.01
	CD, P = 0.01	0.04	0.04	0.04	0.03

Table 3: Total phenol content (mg/g fresh wt.) in healthy plants of mungbean at different stages during Kharif 2017

Sr. No.	Cultivar	Total phenol content (mg/g)	
		15 DAS	30 DAS
1	AKM 12-14 (S)	0.28	0.33
2	AKM 10 11 (S)	0.28	0.32
3	SML 1811 (MR)	0.33	0.39
4	AKM 12 06 (MR)	0.37	0.42
5	HUM 6 (R)	0.42	0.48
6	IPM 312-9 (R)	0.46	0.48
	F test	Sig	Sig
	SE (m±)	0.01	0.01
	CD, P = 0.01	0.04	0.04

Table 4: Total phenol content (mg/g fresh wt.) in healthy and YMV infected plants of mungbean during summer 2018.

Sr. No.	Genotypes	Total phenol content (mg/g)			
		15 DAS		30 DAS	
		Healthy	Infected	Healthy	Infected
1	AKM 12-14 (S)	0.32	0.34	0.36	0.40
2	AKM 10 11 (S)	0.34	0.37	0.40	0.43
3	SML 1811 (MR)	0.39	0.44	0.46	0.50
4	AKM 12 06 (MR)	0.43	0.47	0.44	0.48
5	HUM 6 (R)	0.50	0.56	0.63	0.69
6	IPM 312-9 (R)	0.56	0.63	0.63	0.70
	F test	Sig	Sig	Sig	Sig
	SE (m±)	0.02	0.02	0.02	0.01
	CD, P = 0.01	0.08	0.07	0.10	0.06

Table 5: Total sugar content (mg/g fresh wt.) in healthy plants of mungbean at different stages during Kharif 2017.

Sr. No.	Genotypes	Total sugar content (mg/g)	
		15 DAS	30 DAS
1	AKM 12-14 (S)	2.70	3.03
2	AKM 10 11 (S)	2.73	3.13
3	SML 1811 (MR)	3.07	3.43
4	AKM 12 06 (MR)	3.30	3.60
5	HUM 6 (R)	3.40	3.77
6	IPM 312-9 (R)	3.57	3.97
	F test	Sig	Sig
	SE (m±)	0.067	0.069
	CD, P = 0.01	0.29	0.30

Table 6: Total sugar content (mg/g fresh wt.) in healthy and YMV infected samples of mungbean during summer 2018.

Sr. No.	Genotypes	Reaction	15 DAS		30 DAS	
			Healthy	Infected	Healthy	Infected
1	AKM 12-14	Susceptible	3.16	2.98	3.37	3.11
2	AKM 10 11	Susceptible	3.28	3.01	3.45	3.21
3	SML 1811	Moderate resistant	3.50	3.03	3.56	3.11
4	AKM 12 06	Moderate resistant	3.58	2.86	3.43	3.07
5	HUM 6	Resistant	3.69	3.20	3.86	3.13

6	IPM 312-9	Resistant	3.81	3.13	3.91	3.16
	F test	-	Sig	Sig	Sig	Sig
	SE (m±)	-	0.031	0.031	0.018	0.056
	CD, P = 0.01	-	0.13	0.13	0.078	0.24

Conclusions

In general higher protein content was observed in YMV resistant genotypes of mungbean followed by moderately resistant and susceptible. The increased protein content was observed in infected plants compared to healthy plants of all the genotypes. Higher phenol content was observed in YMV resistant genotypes of mungbean followed by moderately resistant and susceptible. The increased phenol content was observed in infected plants compared to healthy plants of all the genotypes. Higher sugar content was observed in YMV resistant genotypes of mungbean followed by moderately resistant and susceptible. The decreased sugar content was observed in infected plants compared to healthy plants of all the genotypes.

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