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RESEARCH PAPER

Spectral indices as predictive tools for evaluating mungbean yellow mosaic virus resistance

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Abstract: Mungbean is a protein-rich, nitrogen fixing pulse crop and nutritionally known as "Queen of pulses".Its productivity is severely constrained by *Mungbean yellow mosaic virus* (MYMV). Reliable and rapid assessment of disease severity is essential for resistance breeding as conventional visual scoring is often subjective and labour-intensive. This study evaluated the potential of non-destructive spectral tools, SPAD chlorophyll meter readings (SCMR) and the Normalized Difference Vegetation Index (NDVI) as indicators of MYMV resistance in twenty eight pre-screened mungbean genotypes under field conditions at UAS, Dharwad (summer 2025). Results revealed that resistant genotypes (DGG 96 and IPM 2-14) maintained significantly higher chlorophyll content (SCMR: 51.53,48.42 and 49.46, 45.96) and NDVI values (0.76, 0.73 and 0.75, 0.71) at 30 and 45 DAS whereas highly susceptible genotype DGGV 2 exhibited pronounced declines (SCMR: 30.77, 22.21; NDVI: 0.42, 0.33 at 30 and 45 DAS). Moderately resistant entries displayed intermediate physiological responses. The findings confirmed that higher chlorophyll retention and canopy vigour are closely associated with resistance to MYMV.Thus SCMR and NDVI provide reliable, rapid and non-invasive alternatives to visual scoring and their integration into breeding programs can accelerate the identification and development of durable MYMV-resistant mungbean cultivars.

Key words: *Mungbean yellow mosaic virus*, NDVI, Resistant, SCMR

Introduction

Mungbean (*Vigna radiata* L. Wilczek) is a leguminous crop widely cultivated in tropical and subtropical regions, particularly across East and Southeast Asia, with India recognized as both centre of origin and the world's leading producer. Mungbean is commonly known as moong, greengram and golden gram.It supports food security and nutrition through its high protein content and nitrogen-fixing ability.In India,mungbean is grown in about 5.55 million hectares with the total production of about 3.68 million tonnes and with a productivity of 663 kg per hectare (Anon., 2024). It stands as the third most important short-duration pulse after Chickpea and Pigeonpea, earning the title "Queen of pulses" for its remarkable nutritive value (Markam *et al*., 2018).

Despite its agronomic benefits, the productivity of mungbean crop faces significant challenges from both biotic and abiotic stresses. Among biotic constraints, viral pathogens pose substantial threats, with Yellow mosaic disease (YMD) caused by *Mungbean yellow mosaic virus* causing pronounced reductions in seed quality and overall yield (Barigal *et al*., 2024). The disease is transmitted by *Bemisiatabaci* in a circulative, non-propagative manner.YMD symptoms begin as pale-yellow spots on young leaves, progressing to a mosaic pattern that reduces photosynthesis and crop yield. Severe infection leads to poor flowering, fewer pods, shrivelled seeds and in some genotypes, complete crop loss if infection occurs early (Rohit *et al*., 2023).

Reliable disease assessment is crucial for designing effective breeding and management strategies. Traditional visual scoring, although commonly used, suffers from subjectivity and is impractical for large-scale studies. Therefore rapid non-destructive spectral methods are increasingly preferred, notably the Soil Plant Analysis Development (SPAD) chlorophyll meter and the Normalized Difference Vegetation Index (NDVI). SPAD estimates chlorophyll levels, while NDVI provides a broader assessment of canopy vigour and stress (Rouse *et al*., 1974). Although reduced SPAD and NDVI values signal infection and stress, studies correlating these metrics specifically with MYMV severity in mungbean remain limited. This study explores SPAD and NDVI as predictive, non-invasive disease indicators,aiming to improve physiological monitoring and guide resistance research in mungbean breeding programs.

Material and methods

A field trial was conducted in summer 2025 at Main Agricultural Research Station (MARS), UAS Dharwad using a Randomized Complete Block Design with twenty eight pre-screened mungbean genotypes of varying reactions, including resistant (DGG 96) and susceptible (DGGV 2) checks. Genotypes were planted at 30×10 cm spacing in two rows of 3meter length with two replications. Disease incidence(%) was recorded at 30 and 45 DAS using Wheeler's (1969) formula and genotypes were categorized from immune to highly susceptible on a 0–9 scale (Mayee and Datar, 1986).

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

Chlorophyll content was estimated using SPAD Chlorophyll Meter Readings (SCMR). For each of the twenty eight mungbean genotypes, SCMR values were recorded at 30 and 45 days after sowing. Measurements were taken from three

leaves per plant on five randomly selected plants per genotype, with preference given to the top most exposed leaf.

Normalized Difference Vegetation (NDVI) was recorded using a Green Seeker™ sensor positioned 0.75 to 1m above the crop canopy on cloud free days between 9:00 a.m. and 12:30 p.m. Measurements were recorded at 30 and 45 days after sowing for all twenty eight pre-evaluated greengram genotypes. Higher SPAD and NDVI values indicated healthy plants with greater chlorophyll content and canopy vigour, while lower values reflected diseased plants with reduced photosynthetic activity (Penuelas *et al*., 1994).

Results and discussion

Chlorophyll Content (SCMR Values)

Chlorophyll, essential for photosynthesis, directly influences plant growth and stress tolerance. During viral infections like MYMV, its degradation causes yellowing and reduced photosynthetic efficiency. Maintaining higher chlorophyll levels supports energy production and defence metabolite synthesis, making it a key component of plant resistance.

The present study revealed a clear association between chlorophyll content measured by SCMR values and MYMV resistance among mungbean genotypes. At 30 DAS, resistant genotypes such as DGG 96 (SCMR 51.53) and IPM 2-14 (SCMR 49.46) retained significantly higher chlorophyll levels compared to highly susceptible genotypes like DGGV 2 (SCMR 30.77), BGS 9× AKM-9901 (SCMR 34.10) and IPM 02-03 (SCMR 33.19). This trend persisted at 45 DAS, with resistant genotypes maintaining higher SCMR values (DGG 96: 48.42; IPM 2-14: 45.96) while susceptible and highly susceptible entries continued to show pronounced chlorophyll loss (DGGV 2: 22.21; IPM 02-03: 23.74). Moderately resistant genotypes displayed intermediate SCMR values at both growth stages, suggesting partial tolerance to MYMV-induced chlorophyll degradation (Table 1 and Fig.1).

Chlorophyll retention is strongly associated with disease resistance across crops. Resistant mungbean lines maintained

Table 1. Physiological Assessment of *Mungbean yellow mosaic virus* resistance using chlorophyll content (SCMR) and NDVI

Genotype	Per cent disease incidence	Disease reaction	Chlorophyll content using SPAD		NDVI	
			30 DAS	45 DAS	30 DAS	45 DAS
DGG20	24.87 (29.89)	MS	37.61	30.58	0.54	0.52
DGG51	26.82 (31.18)	S	36.81	30.21	0.53	0.49
DGG59	27.78 (31.76)	S	36.63	30.20	0.53	0.49
IPM 02-03	65.00 (53.71)	HS	33.19	23.74	0.48	0.40
DGG274	20.89 (27.18)	MS	37.92	32.04	0.56	0.54
DGG263	23.21(28.79)	MS	37.78	31.09	0.55	0.52
DGG96	0.98 (5.68)	R	51.53	48.42	0.76	0.73
DGG215-5	4.58 (12.35)	MR	41.76	38.79	0.68	0.62
DGG218	3.76 (11.17)	MR	45.77	40.23	0.73	0.66
DGG205	26.56 (30.98)	S	37.12	30.38	0.54	0.50
DGG201	14.00 (21.95)	MS	38.32	33.01	0.61	0.59
DGG211	11.25 (19.59)	MS	38.84	34.63	0.64	0.60
DGWG 53	17.11 (24.42)	MS	38.28	32.36	0.58	0.55
DGG199	12.51 (23.02)	MS	38.48	33.77	0.62	0.59
DGG208	11.05 (19.4)	MS	39.02	34.85	0.64	0.61
DGG122	12.50 (20.7)	MS	38.65	33.98	0.63	0.60
DGG62	13.75 (21.75)	MS	38.36	33.46	0.62	0.59
436714(50)	3.77 (11.19)	MR	42.67	39.13	0.70	0.63
DGG113	14.17 (24.61)	MS	38.32	33.01	0.61	0.59
DGG278	28.79 (32.41)	S	36.13	29.13	0.53	0.49
DGG126	6.58 (14.84)	MR	40.72	38.19	0.68	0.62
IPM 2-17-28-1	8.89 (14.72)	MR	39.69	35.83	0.66	0.62
DGG213-1	8.69 (13.16)	MR	40.64	38.14	0.67	0.62
DGG207	36.25 (41.32)	S	34.53	29.00	0.52	0.48
BGS 9×AKM-9901	51.00 (45.57)	HS	34.10	24.32	0.51	0.44
DGG102	9.50 (17.94)	MR	39.16	34.94	0.65	0.61
IPM 2-14(R- Check)	1.00 (5.73)	R	49.46	45.96	0.75	0.71
DGGV 2(S- Check)	86.90 (68.76)	HS	30.77	22.21	0.42	0.33
S.Em±	0.96		1.55	1.83	0.04	0.04
C.D at 5%	2.79		4.54	5.32	0.11	0.10
C.V. (%)	5.40		5.64	7.68	8.73	8.87

DAS: Days after sowing *Arcsine values

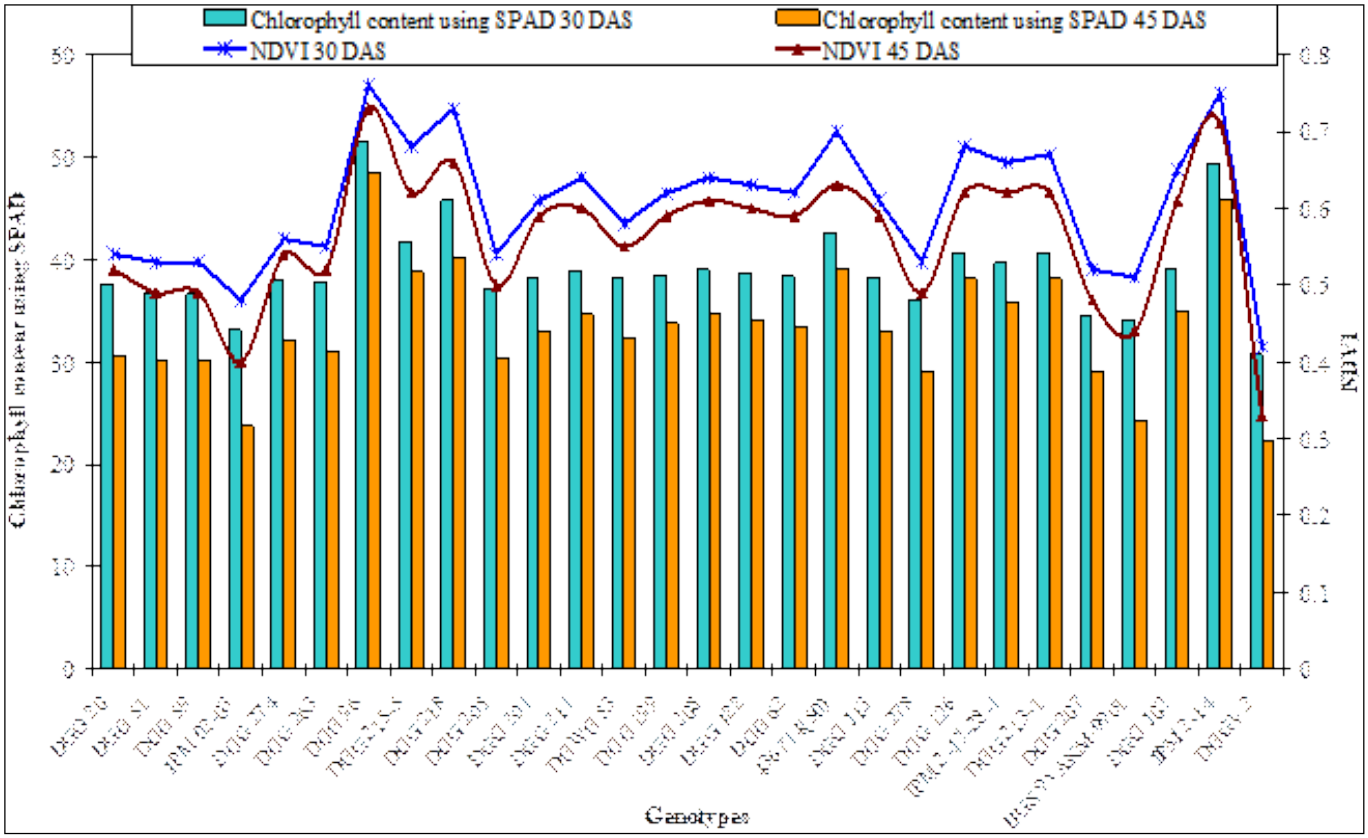

Fig. 1 Physiological assessment of *Mungbean yellow mosaic virus* Resistance using chlorophyll content (SCMR) and NDVI

higher chlorophyll compared to susceptible lines (Mantesh *et al*., 2020), similar observations were recorded in pigeonpea by (Siril, 2022), in soybean and tomato (Lichtenthaler *et al*., 2005). In MYMV infected mungbean, accelerated chlorophyll breakdown and disrupted pigment biosynthesis reduce photosynthetic efficiency, linking chlorophyll loss to greater susceptibility. Thus, sustaining chlorophyll content is a key defence strategy against viral stress (Sinha and Srivasthava, 2010).

Normalized difference vegetation index

NDVI measures canopy greenness using NIR and redlight reflectance, with higher values indicating healthier vegetation (Aditya*et al*., 2025). In context of biotic stress, NDVI serves as a indicator of plant physiological status, reflecting the ability of genotypes to maintain metabolic activity and structural integrity under pathogen pressure.

In this study, MYMV-resistant mungbean genotypes (DGG 96 and IPM 2-14) exhibited significantly higher NDVI values at both 30 and 45 DAS compared to susceptible lines. At 30 DAS, DGG 96 recorded the highest NDVI (0.76) followed by IPM 2-14 (0.75) while highly susceptible genotypes like DGGV 2 (0.42) and IPM 02-03 (0.48) showed markedly lower values. This trend persisted at 45 DAS, with resistant genotypes maintaining superior NDVI readings (DGG 96: 0.73; IPM 2-14: 0.71) whereas susceptible entries such as DGGV 2 (0.33) and IPM 02-03 (0.40) displayed progressive declines in canopy health. Moderately resistant genotypes (DGG 215-5, DGG-126) occupied an intermediate range, aligning with their partial tolerance to MYMV (Table 1 and Fig.1).

The findings corroborate earlier research linking NDVI to disease resistance. For instance, Mahlein *et al*. (2013) demonstrated that NDVI effectively discriminates between healthy and virus infected sugar beet plants with resistant cultivars maintaining higher indices. MYMV disrupts chloroplast structure and function in susceptible plants leading to reduced NDVI (Kumar *et al*., 2011).

Conclusion

This study demonstrated that physiological traits such as chlorophyll content (SCMR) and NDVI serve as reliable indicators of MYMV resistance in mungbean. Resistant genotypes like DGG 96 and IPM 2-14 consistently retained higher chlorophyll levels and canopy vigour compared to susceptible and highly susceptible genotypes, which showed rapid declines due to chlorophyll degradation and canopy loss. The results highlight the potential of SPAD and NDVI as non-destructive and rapid tools for disease assessment. Their integration into breeding programs can enhance screening efficiency, facilitate early detection of stress and accelerate the development of durable MYMV-resistant mungbean

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