Research Article

Field Screening of Mungbean × Mashbean Inter-Specific Recombinant Genotypes Against Yellow Mosaic Disease (YMD)

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Abstract | Yellow mosaic disease (YMD) caused by mungbean yellow mosaic India virus (MYMIV) is an important constraint of mungbean during the summer season in Pakistan. The use of resistant varieties is the only way to reduce the losses caused by YMD. Resistant sources had already been reported in mungbean, but no such information seems to be available for mung × mash interspecific recombinants. In this study, 72 mung × mash interspecific recombinant genotypes and a susceptible mungbean variety Mung Kabuli were screened against Yellow Mosaic Disease (YMD) using disease severity ratings by visual scoring of symptoms to calculate percent disease index (PDI). Tested recombinants responded differently to the disease. None of the tested genotypes was found to be disease free (field immune). However, combined data showed that 43 genotypes were highly resistant with 1.18 to 10 PDI while 29 were resistant with 10.24 to 24.85 PDI. Mung Kabuli (positive control) showed susceptible response with PDI value of 60 %. Thus 43 highly resistant genotypes proved to be a good source of resistance to YMD despite high disease pressure and can, therefore, be used directly as varieties to manage the disease after evaluation for acceptable agronomic characteristics, adaptation, and stability in various regions or can be used as a resistant source in further breeding programs.

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Introduction

Mungbean (*Vigna radiata* L. Wilczek) is an excellent source of protein and an important short duration grain legume crop in humid and sub-humid climate of the world (Akhtar et al., 2011). Different metabolic processes occurring in a plant culminate in the final product, i.e., yield. Any disruption/disturbance in one or more of such processes caused due to biotic and abiotic stresses faced by the plant may reduce the actual yield, and due to these stresses, the average yield of mungbean is low. Among these stresses, diseases are the major causes of low yield (Malik and Bashir, 1992). The severity of various stresses is largely due to varying weather conditions that prevail throughout the year and may extend to next coming years, thus, lowering yield of pulses at farmer's field and keeping it below the potential yield/economic level. The low yielding cultivars and susceptibility to diseases particularly to YMD transmitted by whitefly (*Bemisia tabaci* Genn.) are the major constraints causing low seed yield. YMD, caused by mungbean yellow mosaic India virus (MYMIV) is very devastating in Pakistan especially in the summer season

(Malik, 1991). The disease is characterized by the appearance of yellow specks or spots on young leaves, and the emerging trifoliate leaves manifest irregular yellow and green patches causing a reduction in leaf size. In severe cases, there is complete yellowing of leaves followed by stunted growth, few flowers, and pods maturing late with shriveled seeds. YMD is also the major threat to mungbean production in India, Sri Lanka, Bangladesh, Papu New Guinea, Philippines and Thailand (Malik and Bashir, 1992; Honda et al., 1983; Chenulu and Verma, 1988; Varma et al., 1992; Jones, 2003) and inflict on heavy yields losses annually. According to an estimate yellow mosaic of mungbean, urdbean, cowpea and soybean induced an annual yield loss of US$300 million in India (Varma et al., 1992). The disease incidence of MYMV ranged from 4-40% in Pakistan (Malik and Bashir, 1992) depending upon crop variety and location, leading to 100% yield losses (Ilyas et al., 2010). However, in naturally infected susceptible cultivars it varies with the time of infection and yield losses may reach up to 100% (complete crop failure).

Therefore, the use of resistant varieties is the only way to reduce the losses caused by YMD. Resistant sources had already been reported in mungbean but no such information seems to be available for interspecific recombinants. Most of the available resistance sources reported in the literature do not provide complete resistance against YMD. Furthermore, there are reports of resistance breaking strains appearance of MYMV that overcome already available resistance sources. Therefore, to broaden the genetic base of MYMV resistance in mungbean and to mitigate its resistance breaking strain there is dire need to develop/identify new resistant sources. So, keeping this fact in view, we planned the present study to check the response of mungbean × mashbean interspecific recombinants against YMD and to examine whether the resistance present in parents is transferred in recombinant genotypes or not.

Materials and Methods

Seventy-two true breeding recombinant genotypes developed through inter-specific hybridization between mungbean and mashbean at NIAB, Faisalabad were evaluated in the field for their response against YMD in a Randomized Complete Block Design (RCBD) with three replications during the summer season in 2015. Two rows of each entry were sown in a row plot of 2.1 m^2 keeping row to row and plant to plant distances of 30 cm and 10 cm, respectively. Two to three seeds per hill were dibbled and after germination thinning was done to maintain a single healthy plant per hill. One row of susceptible check Mung Kabuli was planted after every test entry. As the disease spread through whitefly, the crop was sown late about 15 days after the sowing of another surrounding field with mungbean to exert maximum inoculums pressure before the disease screening nursery establish. Fertilizer was applied at the rate of one bag DAP per acre. The weedicide (Dual Gold) was also sprayed on the soil before sowing to avoid excessive weeds. Irrigation was applied to the experiment at flowering and pod filling stages. No plant protection measures were applied against whitefly to ensured high inoculum pressure throughout the growing season. All other agronomic practices were kept uniform. The experiment was observed weekly, and data for disease symptom severity was recorded according to the rating system described in Table 1 to calculate percent disease index (PDI) and the level of resistance/susceptibility of the genotypes (Akhtar et al., 2011).

Results and Discussion

A low level of vector whiteflies *Bemisia tabaci* started to appear immediately after germination and it continued its buildup during the whole growth period of the crop. The first disease symptoms were started as scattered few small yellow spots on few young leaves of susceptible positive control Mung Kabuli after 20-23 days of germination. The number of infected plants and disease severity values increased with the passage of time depending upon the genetic makeup of genotypes. Plants of the susceptible control Mung Kabuli infected at an early stage of growth expressed severe disease symptoms like complete yellowing or chlorosis followed by necrosis within 10-12 days of infection.

The response of the tested interspecific recombinants ranged from highly resistant to resistant, although the severity of YMD varied extensively (1.18% to 24.85%) depending upon the genotypes used in the present study (Table 2). None of the tested recombinants were observed to be field immune (totally free from disease symptoms). Minimum PDI of 1.18% was recorded in MMH 15521 followed by MMH 53105 (1.46%) and MMH 5615 (1.91%). While the recombinant genotype MMH 1143 had maximum

Table 1: *Disease Scale for rating of Mungbean Yellow Mosaic Disease (MYMD).*

Rating/Disease severity*	Symptoms	Percent Disease Index*	Disease reaction
0	**Complete absence of symptoms**	0	**Field immune**
1	Few small yellow specks or spots on few leaves seen after careful observations.	0.01- 10	Highly resistant
2	Bright yellow specks or spots common on leaves, easily observed and some coalesced.	10.01- 25	Resistant
3	Mostly coalesced bright yellow specks or spots common on leaves, but no or minor reduction in yield.	25.01-40	Tolerant
4	Plants showing coalesced bright yellow specks or spots on all leaves, with no or minor stunting and set fewer normal pods.	40.01 - 60	Susceptible
5	Yellowing or chlorosis of all leaves on whole plant followed by necrosis, shortening of internode and severe stunting of plants with no yield or few flowers & deformed pods produced with small, immature and shriveled seeds.	> 60.01	Highly susceptible

**The percentage disease index was calculated as (sum of all disease ratings/total number of plants) x 20.*

disease index (24.85%). Out of 72 interspecific recombinants, 43 genotypes (MMH 1125, MMH 1312, MMH 210115, MMH 3132, MMH 3145, MMH 3563, MMH 3615, MMH 4335, MMH 4615, MMH 53105, MMH 5615, MMH 4224, MMH 2225, MMH 24425, MMH 2413, MMH 2424, MMH 2435, MMH 4135, MMH 4174, MMH 4215, MMH 4255, MMH 4282, MMH 4295, MMH 16211, MMH 5153, MMH 8142, MMH 7112, MMH 9111, MMH 9125, MMH 10212, MMH 12133, MMH 15135, MMH 6235, MMH 2234, MMH 28415, MMH 3221, MMH 15521, MMH 8625, MMH 11534, MMH 11543, MMH 16111, MMH 16311 and MMH 7124) were found to be highly resistant with a PDI ranged between 1.18 to 10% (Table 2). Remaining 29 recombinant genotypes (MMH 7142, MMH 28435, MMH 1143, MMH 1151, MMH 13115, MMH 2112, MMH 2121, MMH 2122, MMH 2131, MMH 2133, MMH 2333, MMH 4211, MMH 2212, MMH 4381, MMH 7111, MMH 16321, MMH 7131, MMH 7252, MMH 8231, MMH 1171, MMH 15334, MMH 23413, MMH 1115, MMH 11315, MMH 37414, MMH 16425, MMH 16435, MMH 21235 and MMH 23422) were observed to be resistant with PDI of 10.24 to 24.85%. However, few small yellow specks or spots on few leaves (3-10% leaves) were observed on infected plants of highly resistant recombinants. Most of the plants of highly resistant recombinants showed complete recovery at advanced stages. The reason may be, after the infection with virus plants of these genotypes restricted the pathogen at the site of infection retaining their normal health as previously reported by Kundu and Pal (2012). While infected plants of genotypes responding as resistant showed bright yellow specks commonly observed on leaves, however, no increase in disease severity was observed in plants of these recombinants till the end of the experiment. The interspecific recombinants viz. MMH 15521, MMH 1125, MMH 3132, MMH 3563, MMH 3615, MMH 4615, MMH 53105 and MMH 5615 had less than 3 PDI exemplifying successful exposition of the YMD-resistant tract in these recombinant genotypes: hence can be used as a resistant source in further breeding programs. Our results are in accordance with the earlier findings of Ahmad (1975), Pandya et al. (1977), Gill et al. (1983), Naqvi et al. (1995), Singh et al. (1996), Saleem et al. (1998), Bashir et al. (2006), Shad et al. (2006), Akhtar et al. (2009), Akhtar et al. (2011), Kitsanachandee et al. (2013), Karthikeyan et al. (2014) and Mahalingam et al. (2018) who reported that resistance in mungbean against YMD is rare.

In Pakistan YMD remains a serious problem throughout. Many research organizations especially NIAB, Faisalabad developed YMD resistant varieties but the causal pathogen is a geminivirus that can change its strain very quickly against a resistant source and a resistant variety became susceptible after few years of release with the emergence of a new strain as previously reported in case of cotton in Pakistan (2010). Thus, a continuous effort is needed for the identification of new sources of resistance with wider genetic base.

Table 2: *Field response of Mung × Mash inter-specific recombinant genotypes against mungbean yellow mosaic disease (MYMD).*

Genotype	Parentage	Percent Disease index	Disease response	Genotype	Parentage	Percent Disease index	Disease response
MMH 1125	NM 92 × Mash-97	2.76	HR	MMH 4381	NM 2006 × Mash-88	10.95	R
MMH 1312	NM 92 × Mash-97	4.00	HR	MMH 16211	VAR.6601×Mash 3-156-1	7.88	HR
MMH 210115	NM 92 × Mash-97	6.84	HR	MMH 7111	NM 2006 × Mash-88	10.30	R
MMH 3132	NM 92 × Mash-97	2.27	HR	MMH 16321	VAR.6601×Mash 3-156-1	15.10	R
MMH 3145	NM 92 × Mash-97	8.95	HR	MMH 7131	NM 2006 × Mash-88	12.09	R
MMH 3563	NM 92 × Mash-97	2.59	HR	MMH 5153	NM 92 × Mash-97	6.06	HR
MMH 3615	NM 92 × Mash-97	2.08	HR	MMH 7252	NM 2006 × Mash-88	21.08	R
MMH 4335	NM 92 × Mash-97	3.03	HR	MMH 8142	NM 2006 × Mash-88	4.89	HR
MMH 4615	NM 92 × Mash-97	2.79	HR	MMH 8231	VAR. 6601 × Mash 3	11.67	R
MMH 7142	NM 2006 × Mash-88	13.33	R	MMH 7112	VAR. 6601 × Mash 3	9.78	HR
MMH 53105	NM 92 × Mash-97	1.46	HR	MMH 9111	VAR. 6601 × Mash 3	5.50	HR
MMH 5615	NM 92 × Mash-97	1.91	HR	MMH 9125	VAR. 6601 × Mash 3	5.60	HR
MMH 28435	VAR.6601×Mash 3-156-1	15.68	R	MMH 10212	VAR. 6601 × Mash 3	5.53	HR
MMH 1143	NM 2006 × Mash-88	24.85	R	MMH 12133	VAR. 6601 × Mash 3	6.07	HR
MMH 1151	NM 2006 × Mash-88	15.61	R	MMH 1171	NM 2006 × Mash-88	16.50	R
MMH 13115	VAR.6601×Mash 3-156-1	12.89	R	MMH 15135	VAR.6601×Mash 3-156-1	6.34	HR
MMH 2112	NM 2006 × Mash-88	10.95	R	MMH 15334	VAR.6601×Mash 3-156-1	10.87	R
MMH 2121	NM 2006 × Mash-88	14.71	R	MMH 6235	NM 2006 × Mash-88	7.73	HR
MMH 2122	NM 2006 × Mash-88	15.26	R	MMH 23413	VAR.6601×Mash 3-156-1	10.46	R
MMH 2131	NM 2006 × Mash-88	13.33	R	MMH 2234	NM 2006 × Mash-88	8.26	HR
MMH 2133	NM 2006 × Mash-88	19.20	R	MMH 28415	VAR.6601×Mash 3-156-1	6.40	HR
MMH 4224	NM 2006 × Mash-88	10.00	HR	MMH 1115	NM 2006 × Mash-88	12.50	R
MMH 2225	NM 2006 × Mash-88	6.67	HR	MMH 3221	VAR.6601×Mash 3-156-1	6.22	HR
MMH 24425	VAR.6601×Mash 3-156-1	8.18	HR	MMH 15521	VAR.6601×Mash 3-156-1	1.18	HR
MMH 2333	NM 2006 × Mash-88	14.63	R	MMH 8625	VAR.6601×Mash 3-156-1	8.29	HR
MMH 2413	NM 2006 × Mash-88	8.00	HR	MMH 11315	VAR.6601×Mash 3-156-1	13.14	R
MMH 2424	NM 2006 × Mash-88	7.50	HR	MMH 11534	VAR.6601×Mash 3-156-1	3.26	HR
MMH 2435	NM 2006 × Mash-88	6.47	HR	MMH 11543	VAR.6601×Mash 3-156-1	7.50	HR
MMH 4135	NM 2006 × Mash-88	8.89	HR	MMH 37414	VAR.6601×Mash 3-156-1	10.24	R
MMH 4174	NM 2006 × Mash-88	8.00	HR	MMH 16111	VAR.6601×Mash 3-156-1	9.47	HR
MMH 4215	NM 2006 × Mash-88	10.00	HR	MMH 16311	VAR.6601×Mash 3-156-1	5.64	HR
MMH 4211	NM 2006 × Mash-88	11.25	R	MMH 7124	NM 2006 × Mash-88	6.25	HR
MMH 2212	NM 2006 × Mash-88	21.67	R	MMH 16425	VAR.6601×Mash 3-156-1	12.86	R
MMH 4255	NM 2006 × Mash-88	4.65	HR	MMH 16435	VAR.6601×Mash 3-156-1	20.89	R
MMH 4282	NM 2006 × Mash-88	8.29	HR	MMH 21235	VAR.6601×Mash 3-156-1	16.60	R
MMH 4295	NM 2006 × Mash-88	6.84	HR	MMH 23422	VAR.6601×Mash 3-156-1	11.36	R
				Mung Kabuli		60.00	S

***MMH:** *Mung × Mash Hybrid;* **HR:** *Highly Resistant;* **R:** *Resistant;* **S:** *Susceptible.*

Conclusion

The use of resistant varieties is the only way to reduce the losses caused by YMD. In present study, the interspecific recombinant genotypes i.e. MMH 15521, MMH 1125, MMH 3132, MMH 3563, MMH 3615, MMH 4615, MMH 53105 and MMH 5615 were found to be highly resistant with minimum PDI value. These genotypes, therefore, can be either released as new varieties or may be used as resistant source in further breeding programs.

Author's Contribution

Ghulam Abbas and Muhammad Ahsan developed the basic idea. Ghulam Abbas and Fiaz Ahmad conducted the field experiment. Khalid Pervez Akhtar recorded data and prepared the draft manuscript. Muhammad Jawad Asghar performed the statistical analysis and did proofreading of manuscript. Muhammad Rizwan helped in the execution of experiment and preparation of draft manuscript.

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