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GENETIC STUDIES IN MUNG BEAN (*VIGNA RADIATA* (L) WILCZEK)

1. Inheritance of tolerance to mung bean yellow mosaic virus and some morphological characters.

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Abstract

Studies on the inheritance of six characters were carried out in a cross between exotic var. Kabuli and local var. Pak 22 of mung bean having contrasting plant characteristics. Tolerance to mung bean yellow mosaic virus (MYMV) was found to be controlled by a single pair of genes; the F_1 showed intermediate reaction. Short internodal length exhibited monogenic inheritance; the F_1 being intermediate. Erect growth habit appeared to be partially dominant over spreading growth habit and controlled by a single gentic factor. The black colour of ripe pod and non-shattering pod character were found to be dominant over dark brown colour and shattering pod respectively; each controlled by a single pair of genes. Round pod shape expressed complete dominance over flat pod shape in F_1; the character seemed to be governed by more than three gene pairs. Due to absence of linkage between susceptibility to MYMV and short inter-nodal length and between spreading growth and short inter-nodal length characters expressed by parent kabuli, it was possible to select plants having erect growth habit, short inter-nodal length and tolerance to MYMV in the F_2 and subsequent generations. The scope for improving plant type of local mung bean cultivars through hybridization has been discussed.

Introduction

Mung bean (*Vigna radiata* (L.) Wilczek) is an important short duration pulse crop of Pakistan and many Asian countries where the diet is mostly cereal based. It is highly prized for its rich seed protein and excellent digestibility (Rachie & Roberts, 1974). Large seed size in mung bean gets the consumer preference and fetches premium in the market. The local mung bean cultivars are invariably small seeded, but well adopted to both spring and summer crop seasons. The exotic large seeded varieties tested so far fail to thrive in summer, our major crop season, largely due to mung bean yellow mosaic virus disease. When grown in spring most of them suffer the disadvantage of pod shattering at maturity and necessitate two to three hand pickings to lift the crop, which is not feasible in the present day farming practices.

The breeding efforts for the improvement of mung bean in the country have been mainly confined to the collection and evaluation of local and exotic germplasm and no information is available about the gentic response of different plant characters in the local cultivars.

For incorporating large seed size in the local mung bean cultivars and also improving their yield, an exotic variety having large seed size was crossed with a local small seeded cultivar. The diversity in the morphological characteristics of the varieties used in the crosses also provided an opportunity to gain some information about the genetic behaviour of local cultivars. The mode of inheritance of mung bean yellow mosaic virus and of some morphological characters studied in this cross are presented.

Materials and Methods

Two varieties, Kabuli and Pak 22 of mung bean (*Vigna radiata* (L) Wilczek) having contrasting plant characters were used. Kabuli, probably introduced from Iran, is extremely short statured, has spreading growth habit, short internodal length, longer flat shattering type black pods, larger seed size but highly susceptible to mung bean yellow mosaic virus (MYMV). Pak 22, a local cultivar has tall and erect growth habit, longer internodal length, short non-shattering type dark brown pods, small seed size but tolerant to MYMV.

Reciprocal crosses between the two varieties were made during spring 1980 in the field grown plants using the technique described by Boling *et al* (1961). The F_1 was grown in spring 1981. The F_2 population alongwith F_1 and parents were grown in summer 1981. In spring 1982, the F_2 generation alongwith F_1 and parents were again grown to study the inheritance of plant characters which could not be studied in summer due to MYMV infection. All the F_2 plants from spring crop 1982 were harvested separately and grown in summer, 1982 as F_3 lines. The sowings were made in rows 4 m long. The row to row and plant to plant spacings were 30 cm and 10 cm respectively. Kabuli was replicated after every 5 rows as a spreader to intensify YM infection from natural resources. No insecticide was applied in order to maintain high population of the vector, the white fly (*Bemesia tabacci* Genn).

Observations on YM infection were taken when the plants were 4-5 weeks old, when 100% plants in the spreader line were completely infected with YM. Reaction to YM appeared as bright yellow patches to complete yellowing of the leaves and other plant parts. The disease severity was scored on a 0-9 scale where 0 = completely free; 5 = restricted yellow patches covering 21-30% of leaf area; 8 = yellow mottle covering 51-60% of plant parts and 9 = complete yellow mottle often leading to death of plants at early stages of growth. The plants in F_1, F_2 and F_3 generations were classified as tolerant (5 score), moderately susceptible (8 score) and susceptible (9 score) since the tolerant and susceptible parents and the heterozygous plants showed the mean disease score of 5, 9 and 8, respectively. Although the parents and F_1 hybrids exhibited wide differences in their reaction towards YM, the rate of infection on the plants within a population was more or less uniform.

The observations on other plant characters viz., growth habit, internodal length, pod colour and shape and pod shattering habit in the F_1 and F_2 alongwith the parents were recorded at maturity. In the F_3, individual plants from each F_3 line were scored on the basis of individual plant reaction to YM. Each family was classified as tolerant, segregating and susceptible. The same F_3 lines were classified by visual observations as having long internodes, segregating and short internodes at maturity. Based on the F_2 and F_3 generations data joint segregation of different plant characters was investigated to know if there was any association between them.

Results

Inheritance of tolerance to mung bean yellow mosaic virus: The results of disease reaction of parents, F_1, F_2 and F_3 populations are presented in Table 1.

Table 1. Inheritance of reaction to mung bean yellow mosaic virus.

Parent			No. of F_2 plants					
Susceptible	Tolerant	F_1	Susc.	Mod. Susc.	Tol.	Total	x^2 (1:2:1)	P
Kabuli	Pak 22	Intermed (Mod. Susc.)	86	177	89	352	.0625	0.95-0.97
*Behaviour of 158 selfed F_2 plants raised as F_3 families.								
79 F_3 families showed segregation			728	1492	748	2968	.3558	0.80-0.90
38 F_3 families bred true for susceptibility.								
41 F_3 families bred true for tolerance.								

*Plants taken from F_2 generation grown in spring, when there was no disease in the field conditions.

All the plants of tolerant parent Pak 22 showed the appearance of yellow patches on their leaves covering nearly 25% of the leaf area and tended to recover while nearing maturity. In susceptible parent Kabuli, the YM appeared very early and soon became wide spread and severe infecting 90-100% area of the leaves and other plant parts during the first 2-3 weeks of their growth. The plants remained stunted and most of them wilted before flowering. All the F_1 plants exhibited moderate susceptibility to YM. The symptoms appeared as large yellow patches covering about 60% area of the leaves, stem and other plant organs with marked reduction in flowering and seed formation. The F_2 population, segregated in 1 susc.: 2 mod. susc.: 1 tol. classes indicating that tolerance to YM was controlled by a single pair of genes. The intermediate behaviour of F_1 plants with respect to intensity of disease infection (Fig 1) also indicated that this trait is

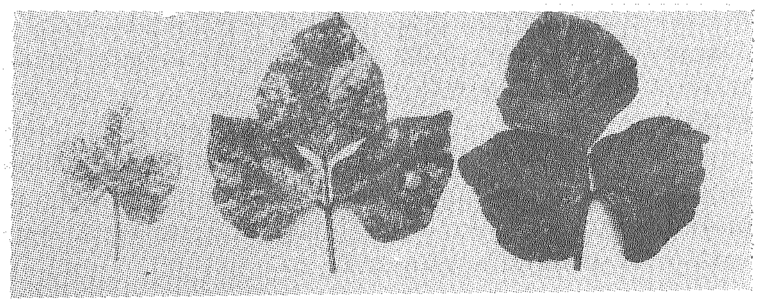

Fig. 1: Incidence of Mung bean Yellow Mosaic Virus on leaves of mung bean varieties Kabuli (left), Pak 22 (right) and their F_1 (Centre).

inherited quantitatively. Of the 158 F_2 single plant progeny rows, 79 showed segregation for this character in the F_3 generation giving a good fit to 1:2:1 ratio confirming the results obtained in the F_2. The remaining 38 and 41 families bred true for susceptibility and tolerance to YM respectively.

Inheritance of growth habit: The plants of parent Pak 22 were tall (80-90 cm), erect had longer internodes (middle internodal length = 5 cm), and branches arising from these nodes pointed upwards forming an angle of $45^o - 50^o$ with the main axis. The plants of parent Kabuli were spreading and conspicuously shorter with an average height of 20 cm. Their internodes were very short (0.89 cm) and the angle of branches arising from the main stem ranged from $90^o - 100^o$. The dwarfing in parent kabuli was in fact due to very much reduced internodal length, although the number of nodes forming on the main axis in both the parents was the same.

The F_1 was intermediate but indicated partial dominance of the erect nature. Among the segregating F_2 progeny the spreading plants were conspicuously different from the erect and intermediate plants. The results (Table 2) indicated monogenic inheritance of the growth habit with incomplete dominance of erect type.

Table 2. Inheritance of erect x spreading habit.

Parents			No. of F_2 plants				x^2	
Erect	Spreading	F_1	Erect	Intermed.	Spreading	Total	(1:2:1)	P
Pak-22	Kabuli	Inter-mediate	39	79	40	158	0.01	0.99-0.995

Inheritance of internodal length: The data for internodal length character was recorded from both spring and summer grown populations. The F_1 was intermediate. The

F_2 progeny segregated in distinct, 1 long: 2 intermediate: 1 short internodal length classes (Table 3) indicating monogenic inheritance for internodal length.

Table 3. Inheritance of internodal length.

Parents		F_1	No. of F_2 plants				x^2	P
Long inter-node	Short inter-node		Long inter-node	Inter-med.	Short inter-node	Total	(1:2:1)	
Pak 22	Kabuli	Inter-mediate	*39	82	37	158	0.28	0.75-0.90
			**95	175	82	352	0.97	0.50-0.75

*Spring crop population **Summer crop population

Inheritance of ripe pod colour: As the pods reached maturity two types of colours could be distinguished. Black in parent Kabuli and tan in parent Pak 22. The pigments were seen to develop in hypodermis and then gradually extended to parenchymatous layer below. The tan colour changed to dark brown in humid weather conditions. The mode of inheritance of the pod colour is given in Table 4.

Table 4. Inheritance of ripe pod colour.

Parents		F_1	No. of F_2 plants			x^2	P
Black	Dark brown		Black	Dark brown	Total	(3:1)	
Kabuli	Pak-22	Black	117	41	158	0.08	0.75-0.90

The pods of F_1 were black in colour. The F_2 progeny segregated in the ratio of 3 black to 1 dark brown indicating monogenic dominance of the black over tan or dark brown pod colour.

Inheritance of pod shape: The pod shape of parent Pak 22 was round whereas parent Kabuli produced flat pods with marked constrictions between grains. In F_1, round pod shape was found to be dominant over flat. In the F_2 none of the progeny produced flat pod indicating that round shape of the pod was a polygenic trait.

Inheritance of pod shattering: The pods of parent Kabuli were highly prone to shattering. The mature pods tended to split open while intact on the plants resulting in huge grain yield losses. The pods of parent Pak 22 were non-shattering type and did not split unless they were subjected to threshing. The pods produced by F_1 plants were non-shattering type. The F_2 progenies segregated into non-shattering and shattering types in the freqency given in Table 5. The results indicated that non-shattering pod character was dominant over shattering pod and was controlled by a single genetic factor.

Table 5. Inheritance of non-shattering pod x shattering pod.

Parents		F_1	No. of F_2 plants			x^2	P
Non shat-tering	Shat tering		Non shat-tering	Shat tering	Total	(3:1)	
Pak 22	Kabuli	Non shattering	114	44	158	0.68	0.25-0.50

Studies on joint segregation of some characters: Parent Kabuli expressed spreading growth habit, short internodal length and susceptibility to YM diseases. In order to find out whether there was any association between these important traits, joint segregation of characters viz. growth habit – internodal length and reaction to YM – internodal length were studied in the F_2 populations. The results obtained (Tables 6 and 7) gave a good fit to the expectation of 1:2:1:2:4:2:1:2:1 ratio in both the cases indicating that the above characters segregated independently of each other.

Table 6. Joint segregation of internodal length and growth habit in the F_2 of the cross Pak 22 x Kabuli.

Growth habit	Classification for internodal length			
	Long	Intermediate	Short	Total
Erect	11	20	8	39
Intermediate	19	41	19	79
Spreading	9	21	10	40
Total	39	82	37	158

x^2 for 1:2:1:2:4:2:1:2:1 ratio = 1.3418 P = 0.995-1.00

Among 158 F_3 families (Table 8), 39 were long internodes, 82 were segregating and 37 were short internodes. These data showed a good fit with 1:2:1 ratio expected from monogenic control of internodal length. The reaction of these F_3 families to YM also agreed with 1:2:1 ratio expected for monogenic control of tolerance/susceptibility, thus verifying the results obtained in the F_2. The data from two way classification of 158 families for these two traits gave a good fit to a dihybrid ratio clearly indicating the independent segregation of these two genes.

Table 7. Joint segregation of reaction to yellow mosaic virus (YMV) and internodal length in the F_2 of cross Pak-22 x Kabuli.

Reaction to (YMV)	Classification for internodal length			
	Long	Intermediate	Short	Total
Tolerant	25	42	22	89
Intermediate	48	90	39	177
Susceptible	22	43	21	86
Total	95	175	82	352

x^2 for 1:2:1:2:4:2:1:1:1 ratio = 1.5455 P = 0.990-0.995

Discussion

The reciprocal crosses between the tolerant and susceptible parents showed the same degree of disease infection in the present study indicating the involvement of nuclear genes only and free from any cytoplasmic effect. The inheritance data in the F_2 and F_3 generations elicited that tolerance or susceptibility to MYMV was controlled by a single gentic factor. The intermediate behaviour of F_1 plants indicated that this trait also inherited quantitatively. The monogenic control of reaction to MYMV observed during these investigations has also been reported by Thakur *et al* (1977) in mung bean, Taiwo *et al* (1981) in cowpea and Tulmann (1979) in french bean, but in all these reports dominance of susceptibility over resistance/tolerance has been described. From our present and subsequent studies on several intervarietal crosses between mung bean genotypes having varying degrees of tolerance/resistance and susceptibility to MYMV, the F_1's invariably expressed intermediate reaction to the intensity of disease infection as

Table 8. Number of F_3 families of the cross Pak 22 x Kabuli classified for internodal length as long, segregating or short and susceptible, segregating or tolerant to yellow mosaic virus.

Reaction to (YMV)	Classification for internodal length			
	Long	Segregating	Short	Total
Tolerant	12	21	8	41
Segregating	18	42	19	79
Susceptible	9	19	10	38
Total	39	82	37	158

x^2 for 1:2:1:2:4:2:1:2:1 ratio = 1.3418 P = 0.990-0.995

compared to their respective parents. The method adopted in scoring the disease severity may also sometime lead to differences in the evaluations. In the present studies for instance, the tolerant and susceptible parents showed 21-30% and 95-100% disease infection respectively as compared to 51-60% disease infection recorded in the F_1 plants. Based on their intermediate reaction the F_1 plants were scored as moderately susceptible which could also be erroneously scored under susceptible class keeping in view such a high degree of disease infection on them. Singh (1980) in his studies on the inheritance of MYMV in black gram involving highly resistant and highly susceptible donors found the F_1's to be moderately susceptible but in the F_2 generation scored the plants only in resistant and susceptible classes.

There are however, also some reports indicating involvement of two recessive genes for the control of MYMV as reported by Shukla *et al* (1978) in mung bean, Singh & Malick (1978) in soybean, Singh (1980) and Solanki *et al* (1982) in black gram. Solanki (1981) reported both monogenic and digenic control of resistance to MYMV in two sets of crosses involving susceptible and resistant varieties of black gram. The susceptibility was however, found to be dominant in both the crosses. Kuln *et al* (1981) in cowpea reported that virus movement was controlled by a dominant gene in the host. In recessive condition the movement was inhibited. The concentration of virus as well as virus replication seemed to be controlled by several genes. Hobbs (1984) in cowpea reported that resistance to southern bean mosaic virus was conferred by a single gene with partial dominance. The differences in reaction of different species and varieties towards YMV as reported by various workers described above may be attributed to the differences in the genetic make up of species/varieties used in the experiments.

The short internodal length was found to be controlled by single genetic factor in the present studies. Similar results were obtained by Jones (1965) in cowpea. The observed partial dominance of erect growth habit over spreading type commensurate with the report of Sen & Jana (1963) in black gram but not in agreement with the findings of Pathak & Singh (1963) in mung bean, who reported that semi-spreading growth habit was monogenically dominant over erect growth habit.

The dominance of black pod colour over dark brown in the present study is in accord with the findings of Pathak & Singh (1963) who reported monogenic dominance of black colour of the ripe pod over light brown. Shattering of pod at maturity is a serious problem in mung bean. This character behaved as a monogenic recessive in the present investigations. However, Verma & Krishi (1969) showed monogenic dominance of shattering over non-shattering character in mung bean. Singh *et al* (1975) concluded that resistance to shattering was quantitatively inherited. Round pod shape of parent Pak 22 was found to be completely dominant over flat pod shape of parent Kabuli in F_1. In order to find out the number of genes involved in controlling the pod shape larger F_2 population needs to be grown.

The independent segregation of plant characters viz., tolerance to MYMV and short internodal length; spreading growth habit and short internodal length in the F_2 and F_3 generations indicate that the genes controlling these traits in parent Kabuli are located on different chromosomes. In the F_2 and subseqent generations it was possible to identify plants having short internodal length, erect growth habit and tolerance to MYMV. Such genotypes may have their use in the development of short statured varieties for the areas where lodging due to over growth is a problem. The results obtained in the present ivestigations may be helpful in future cross breeding programmes.

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