Pak. J. Bot., 18(1): 75–81, 1986.

GENETIC CHARACTERISATION OF GAMMA IRRADIATION INDUCED LEAF MUTATIONS IN MUNG BEAN (*VIGNA RADIATA* (L) WILCZEK)

ILYAS A. MALIK, G. SARWAR AND Y. ALI

Division of Mutation Breeding,
Nuclear Institute for Agriculture and Biology, Faisalabad, Pakistan.

Abstract

Three new leaf mutants, serrated leaf, unifoliate and narrow leaf were induced in mung bean, *Vigna radiata* (L) Wilczek, following seed treatments with different exposures of gamma irradiation. The serrated leaf mutant was obtained in cultivar Pak 32 at 60 KR whereas unifoliate and narrow leaf mutants were obtained in cultivar 6601 at 30 KR and 60 KR doses, respectively, in the M_2 generation. The serrated leaf mutant had relatively large thick leaflets with conspicuous deep serration of the margins as compared to the entire leaflets of the parent. The pollen fertility in the mutant lines ranged from 42–95%. The mutant behaved as monogenic recessive to normal. The gene symbols Sl/sl are proposed for this allelic pair. The unifoliate mutant was characterised by simple leaves instead of trifoliates whereas the narrow leaf mutant had long narrow leaflets. Both the mutants were slow in their growth and completely sterile. The drastic changes in the morphology and low frequency of the mutants suggested that unifoliate and narrow leaf mutants might be due to chromosomal aberrations.

Introduction

Mutants showing changes in shape and size of the leaf have been reported in a number of species within the family Leguminosae (Gottschalk, 1969; Bayly & Craig, 1962; Appa Rao & Jana, 1976; Basselt, 1981). In mung bean (*Vigna radiata* (L) Wilczek) alterations in the leaf structure induced through radiations or chemical mutagens are also known (Santos, 1969; Ganguli & Bhaduri, 1980; Sareen, 1982), but most of the mutants exhibiting drastic changes have either reduced fertility or become completely sterile. During the course of an investigation on induced mutations in mung bean three new mutant types including one with varying degree of fertility were recovered following seed treatment with gamma irradiation. The morphological characteristics and mode of inheritance of these mutants are reported.

Materials and Methods

Dry dormant seeds of three local mung bean (*Vigna radiata* (L) Wilczek) cultivars viz. 6601, Pak 32 and Rc 71-17 with 12% moisture content of uniform size were treated with 15, 30 and 60 KR exposures of gamma irradiation. Immediately after irradiation the seeds were sown in the field. At maturity 500 M_1 plants from each dose and variety were harvested separately and sown as M_2 rows alongwith untreated controls. Morphological variants were isolated in the M_2 and confirmed as mutants in the M_3 generation. Reciprocal crosses were made between the normal parent and mutant where appropriate. The F_1 plants were selfed and back crossed to study the inheritance pattern of various mutants. Pollen fertility was determined by the stainability of the pollen grains in acetocarmine. Those which stained heavily were regarded as fertile.

Results and Discussion

Mutants showing changes in the leaf characters were recorded from different doses of gamma irradiation. The mutants were named according to the most prominent character, though in most of the mutants more than one character was altered.

Serrated leaf

Origin: Cultivar Pak 32, 60 KR.

Morphology: The morphological characteristics of the mutant as compared to the normal parent are presented in Table 1. The most striking feature of this mutant was the conspicuous deep serration of the leaflets margins as compared to the entire

Table 1. Characters of parent and an induced serrated leaf mutant of mung bean

Characters	Parent	Mutant
Days to flower	51	57
Days to mature	85	90
Plant height (cm)	71.07±1.67	62.40±1.60
No. of pods per plant	27.40±3.37	32.53±2.44
Length of the pod (cm)	7.15±0.05	7.14±0.19
No. of seeds per pod	11.60±0.26	8.13±0.60
Thousand seed weight (gm)	29.58±0.51	46.50±0.54
Length of the 6th leaflet (cm)	10.48±0.20	12.56±0.21
Breadth of the 6th leaflet (cm)	11.58±0.19	15.62±0.17
No. of branches	2.13±0.21	2.73±0.15
No. of pod clusters	10.47±1.09	11.47±0.49
Seed colour-surface	Green-glossy	Yellowish green-glossy
Seed yield per plant (gm)	7.55±1.07	6.37±0.29
Seed protein (%)	22.40	25.56
Pollen fertility (%)	96.70	88.24 (Range 46–95%)

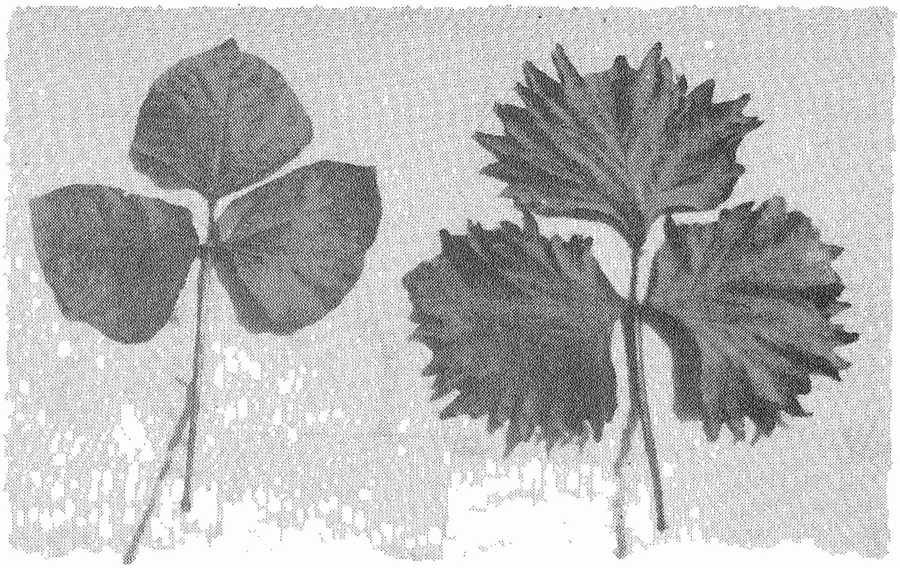

Fig. 1. Leaves of mung bean cultivar Pak 32 (left) and its irradiation induced mutant (right). Noticeable are the deep serration of leaflets margins and increase in size of the leaflets in mutant.

leaflets of the normal parent (Fig. 1). The mutant had large thick leaves with prominent venation. The mutant exhibited slower growth particularly during the early stages of development, flowered late by about a week and attained lesser height than the normal parent. There was an increase in the number of pods, and thousand seed weight and seed protein contents percentage in the mutant but the number of seeds per pod was considerably reduced. The seed coat colour also showed a change from green to yellowish green. In the mutant flowers the stamens were placed much below the stigma level and the stigma sometimes protruded the corolla where as in the normal parent flower the stamens were placed at the same level encircling the stigma. The pollen fertility in the mutant lines ranged from 42 to 95%.

Inheritance: All the serrated leaf plants in the M_2 generation when selfed bred true for this character in the M_3 generation (Table 2). Progenies of four out of eight normal leaf phenotypes from the same M_2 line showed segregation for serrated leaf character in the M_3 generation, indicating a monogenic recessive response. Progenies of 41 out of 68 randomly selected normal leaf segregants from the M_3 lines exhibited segregation for serrated leaf in the M_4 generation while the rest bred true for the normal leaf character.

The F_1 plants from reciprocal crosses between normal and mutant were all normal. In the F_2 they segregated into normal and mutant which was in each case a good fit to

Table 2. Occurrence of serrated leaf mutant in the M_2–M_4 generations and classification of mung bean plants in the F_1, F_2 and back cross populations involving serrated leaf mutant and parent cultivar Pak-32.

Population		Total plants grown	Normal leaf	Serrated leaf	X^2 analysis	P
M_2 generation		11	8	3		
M_3 generation						
(Progenies of selfed M_2 plants)						
Serrated leaf	1)	24	-	24		
phenotypes	2)	7	-	7		
	3)	22	–	22		
Normal leaf						
phenotypes	1)	54	41	13	0.025 (3:1)	0.88
	2)	38	29	9	0.035 (3:1)	0.87
	3)	14	11	3	0.095 (3:1)	0.76
	4)	10	8	2	0.133 (3:1)	0.73
	5)	30	30	–		
	6)	15	15	–		
	7)	3	3	–		
	8)	29	29	–		
M_4 Generation						
(Progenies of 68 normal leaf selfed M_3 segregants)						
Progenies of 41 heterozygous plants		1466	1108	359	0.026 (3:1)	0.64
Progenies of remaining 27 plants bred true for normal leaf						
Normal leaf parent (Cv. Pak 32)		50	50	–		
Serrated leaf mutant		50	–	50		
F_1 (serrated x normal)		15	15	-		
F_1 (normal x serrated)		16	16	–		
F_2 (serrated x normal)		179	138	41	(0.419 (3:1)	0.53
F_2 (normal x serrated)		226	173	53	0.289 (3:1)	0.62
F_1 (Nor. x Serr.) x Serr.		22	12	10	0.182 (1:1)	0.69
F_1 (Serr. x Norm.) x Norm.		16	16	–		

3:1 ratio. The plants from test cross showed a good fit to 1:1 ratio. When the F_1 plants were crossed with the normal parent all the plants were normal. In the F_3 generation, all the serrated leaf F_2 plants bred true. Of the 30 normal F_2 plants, 11 bred true, while the rest segregated in 3:1 ratio. All the available data indicate that the mutant is monogenic recessive to the normal, and the gene symbols Sl/sl are proposed for this allelic pair.

Unifoliate mutant

Origin: Cultivar 6601, 30 KR.

Morphology: The mutant was distinguishable at all the stages of growth. The first pair of leaves were very thick and dark green in colour. The emergence of the subsequent leaves was delayed by about a week. Instead of trifoliate leaves simple leaves were produced. All the leaves were unifoliate and larger in size than the normal leaflets. The leaves were deeply veined and had rough surface. The plant was less vigorous and slow in growth. The emergence of infloresence was delayed by about a fortnight. The mutant failed to produce any well developed floral organs and was thus sterile.

Inheritance: Of the 34 normal looking plants from the same M_2 row in which the unifoliate mutant was identified, one gave 77 normal and 3 unifoliate progeny in the M_3 generation; the other 33 gave only normal. Progenies of all the 77 normal M_3 plants were grown separately as M_4 rows; 2 out of 77 plants showed segregation for this character giving 65 and 50 normal to 2 and 4 unifoliate respectively, the other 75 gave only normal. The low frequency of the mutant and the drastic alterations in the morphology lead to the conclusion that unifoliate mutant might be due to chromosomal aberrations.

Narrow leaf mutant

Origin: Cultivar 6601, 60 KR.

Morphology: The most distinguishing feature of this mutant was its long and narrow first pair of leaves. They were thick and dark green in colour with the margins curved upward. All the subsequent trifoliate leaves were long and narrow showing a characteristic upward curling of the leaf margins in addition to the dark green colour. The mutant had dwarf growth habit with shroter internodes. The emergence of inflorescence was delayed by 17 days. No seeds were obtained from the plant due to abscission of flower buds at the early stages of their development.

Inheritance: From a total of 25 plants in the M_2 row, 2 showed narrow leaf character. Of the remaining 23 normal looking M_2 sister plants; 1 showed segregation giving 60 normal and 2 narrow leaf progeny in the M_3 generation, the other 22 gave only normal. Progenies of all the 60 normal looking M_3 plants were grown separately; only 4 showed segregation giving 35, 55, 60, 51 normal and 2, 3, 2, 4 narrow leaf plants respectively in the M_4 generation, the other 56 gave only normal. The low frequency of the mutant and the drastic changes in the morphological characters suggest that the narrow leaf mutant might as well be the consequence of chromosomal aberrations.

The mutants studied during present investigation showed several characters distinguishing them from the parental types. These differences may be evoked by a high degree of pleiotropism particularly in unifoliate and narrow leaf mutants. An apparent pleiotropic spectrum may not always be due to the action of a single gene but sometimes to that of two or more adjacent independent genes (Goplen, 1967; Gottschalk, 1968; Appa Rao & Jana, 1976).

The unifoliate mutant in mung bean reported by Santos (1969) was also sterile but more vigorous than and flowered at about the same time as the parental type. In the present study the unifoliate mutant was less vigorous and late in flower bud initiation than the parent. The pinnately reticulate venation of the simple leaves also clearly indicated that this unifoliate character was due to the suppression of lateral leaf primordia rather than connation of the leaflets. The unifoliate mutant reported by Appa Rao & Jana (1976) in black gram was also completely sterile due to the rudimentary development of the floral organs described as above. Although most of the unifoliate mutants in the family leguminosae have been found to be completely sterile, some fertile unifoliate mutants have also been reported in crops such as *Vicia faba* (Gottschalk, 1958; Sjodin, 1964), *Phaseolus vulgaris* (Lamprecht, 1935) and *Melilotus albus* (Hartwig, 1941).

In serrated leaf mutant the low number of seeds per pod can be attributed to the reduced pollen fertility in mutant lines. Similar trend for pollen fertility and number of seeds per pod was observed in several normal leaf sister plants in the segregating generations, indicating that reduced pollen fertility in the mutant may not be mainly due to the serrated leaf character. However, the natural outcrossing to the extent of 4% recorded in some of the mutant lines reveal its reduced cliestogamy which seems to be due to certain morphological changes in the floral parts described as above. The serrated leaf mutant may have its use as a green manure crop because of its larger foliage and to the breeders as a genetic marker.

Acknowledgement

The authors are grateful to Dr. S.H. M. Naqvi, Director, Nuclear Institute for Agriculture and Biology, Faisalabad for providing the necessary facilities and reviewing the manuscript.

References

Appa Rao, S. and M.K. Jana. 1976. The leaf mutations induced in black gram by X-rays and EMS. *ENV and Expt. Bot.*, 16: 151–154.

Basselt, M.J. 1981. Inheritance of a lanceolate leaf mutation in the common bean. *Jour. Heredity* 72: 431–432.

Bayly, I.L. and I.L. Craig, 1962. A morphological study of the X-ray induced cauliflower-head and single-leaf mutation in *Medicago sativa* L., *Canad. J. Genet. Cytol*, 4: 386.

Ganguli, P.K. and P.N. Bhaduri, 1980. Effect of X-rays and thermal neutrons on dry seeds of green gram (*Phaseolus aureus* Roxb.) *Genetica Agraria*, 34: 257–276.

Goplen, B.P. 1967. A recessive pleiotropic gene conditioning unifoliate leaves and cauliflower inflorescences in sweet clover. *Canad. J. Genet. Cytol.* 9: 136.

Gottschalk, W. 1958. Uber die genetischen Verhaltnisse einer Komplex-mutants von *Vicia faba. Angew Bot.* 32: 147.

Gottschalk, W. 1968. Simultaneous mutations of closely linked genes. 97–107 in: *Mutation in Plant Breeding,* 11, IAEA, Vienna.

Gottschalk, W. 1969. 'Progressive' mutations in leguminosae. 559–570. in: *Induced Mutations in Plants,* IAEA, Vienna.

Hartwig, E.E. 1941. A new mutant leaf character in sweet clover. *J. Hered.* 32, 171.

Lamprecht, H. 1935. Komplexe und tromologe Mutationen, *Hereditas,* 20, 273.

Sareen, P.K. 1982. Genetic analysis of the trilobate leaf mutant in mung bean (*Vigna radiata* var. aureus (L) Wilczek) *Curr. Sci.* 51: 1028–1029.

Santos, I.S. 1969. Induction of mutations in mung bean (*Phaseolus aureus* Roxb.) and genetic studies of some of the mutants. 169–179. in: *Induced Mutations in Plants,* IAEA, Vienna.

Sjodin, J. 1964. Some unifoliate mutants in *Vicia faba* L. *Hereditas,* 51: 279–290.

(Received for publication 4 December 1985)