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EXPLOITATION OF EXOTIC AND INDIGENOUS MUNGBEAN GERMPLASM FOR IMPROVING SEED YIELD AND DISEASE RESISTANCE

MUHAMMAD SIDDIQUE SADIQ, SAJJAD HAIDAR* GHULAM ABBAS, TARIQ MAHMUD SHAH AND BABAR MANZOOR ATTA

Mutation Breeding Division,
Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, Pakistan.

Abstract

Mungbean (*Vigna radiata* (L.) Wilczek) is an important short duration kharif pulse crop in Pakistan. To enhance genetic variability for large seed size, hybridization between exotic and indigenous germplasm was initiated at Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad in 1980 to improve the yield potential. F_1 were irradiated and top crosses were also made. The improvement programme has culminated in the development of large seeded varieties with high yield potential *i.e.*, NM-51, NM-54, NM-92 and NM-98. A new high yielding, having large seed size and disease resistance mungbean variety i.e., NIAB MUNG 2006 has been approved during 2006 by the Punjab Seed Council for general cultivation in the irrigated tract of the Punjab province. Due to high yield potential, short duration and disease resistance, these varieties were adopted at a faster rate and are grown on 90% of mungbean acreage in the country thus curtailing mungbean import and enhancing mungbean production in the country. The achievements of mungbean improvement programme are discussed.

Introduction

Pulses are an important component of cereal-based diet in Pakistan. It is regarded as quality pulse for its rich protein seed and excellent digestibility, especially when combined with cereals (Thirumaran & Seralathan, 1988; Singh *et al*., 1988; Rachie & Robert, 1974). Cereals are low in lysine and tryptophan whereas pulses are rich in these amino acids. They complement each other and hence enhance the food quality. In a normal mixed diet, protein is derived from several sources like cereals, legumes, milk, meat, fish etc. This obviously helps in overall supplementation and an improvement in the food value than protein from any of its individual constituents like cereals or pulses. Dietary proteins provide amino acids for the synthesis of body proteins and other biological important nitrogenous compounds in the body. Besides being a rich source of protein, these are also important for sustainable agriculture and enriching soil organic matter through biological nitrogen fixation.

Pulses *i.e*., chickpea, mungbean, mashbean, lentil, pea and other minor kharif and rabi pulses are grown on an area of 1492 thousand hectares, which is 7% of the cropped area (22510 thousand hectares). In Punjab, chickpea is grown on an area of 956.4 thousand ha with an annual production of 760.6 thousand tons, which is 87% and 88% of area and production of Pakistan (Table 1), whereas mungbean is grown on an area of 206.6 thousand ha with an annual production of 118 thousand tons, which is 92% and 91% of area and production of Pakistan respectively. Chickpea and mungbean in Punjab cover 64% and 14% pulses area of Pakistan (Anon., 2004-05). Indigenous germplasm is invariably small seeded (30-40 gm) per thousand seed but it is well adapted to both spring and summer seasons. Exotic large seeded accessions when introduced in Pakistan, fail to thrive due to photoperiod sensitivity and susceptibility to MYMV. Intraspecific hybridization has resulted in the development of large seeded varieties, having high seed yield potential alongwith disease resistance. This paper gives an account of the achievements of NIAB mungbean improvement programme.

*Corresponding author E-mail: sajjadhaidar_pk@yahoo.com

Table 1. Area wise distribution of different pulse crops.

Crop	Pakistan (%) *TPA	Punjab (%) *TPA	Punjab (%) of Pakistan
Chickpea	73.3	64.1	87
Mung	15.1	13.8	92
Mash	0.03	0.03	89
Lentil	0.03	0.001	65
Mattar (dry Pease)	0.06	0.001	21
Others (Kharif)	0.004	0.002	43
Others (Rabi)	0.001	0.0004	38

Source: Agriculture Statistics of Pakistan 2004 –2005: * Total pulses area

Materials and Methods

To develop high yielding varieties of mungbean with large seed size and tolerance/resistance to mungbean yellow mosaic virus (MYMV), a local small seeded cultivar 6601 which is tolerant to MYMV was crossed reciprocally with exotic, large seeded types which were highly susceptible to MYMV. The reciprocal crosses between the two varieties were made in the field grown plants using the technique described by Boling *et al*., (1961). At the same time some hybrid seeds were treated with 100Gy gamma rays and were grown to raise an F_1/M_1 generation. The F_2/M_2 was raised in the following seasons.

Hybrids together with the parents and mutants were grown in randomized complete block design (RCBD) with three replications. The spacing between the rows was 30cm and plants were 10cm. Observations were recorded on five competitive plants of the different generations along with the parents. The characters recorded were: days to flowering and maturity, plant height, branch number, cluster number, pod length, seeds per pod, 1000 seed weight, seed yield and response to MYMV. A variety kabuli (highly susceptible to MYMV) was replicated after every four rows as spreader to intensify MYMV infection from natural sources. No insecticide was sprayed in order to maintain high population of vector, the whitefly (*Bemisia tabaci* Genn.). Observations on MYMV infection were taken when 100% of the plants in spreader line were infected with MYMV (the plants were 4-5 week old). The disease severity was scored on 0-9 scale based on visual symptoms (Shukla *et al*., 1978). Analysis of variance for all the characters was carried out following the procedure described by Steel & Torrie (1984).

The selections was made from F_2/M_2 population and single plant progenies were raised from the selected plants for their evaluation/confirmations and breeding behaviour for various traits such as seed size, yield, and diseases viz., Mungbean Yellow Mosaic Virus and *Cercospora* leaf spot (Tables 3, 4). Susceptible checks were included to create epiphytotic condition in the segregating generations. These traits remained under study for confirmation during succeeding generations up to F_6/M_6.

Selected true breeding lines were further evaluated in yield screening nurseries. The advanced lines were evaluated in advanced yield trials. For testing its seed yield and yield stability the advanced lines were further evaluated in the adaptation trials and national yield trials.

Table 2. Seed yield and yield related traits of mungbean varieties developed at NIAB, Faisalabad.

Variety	Year of release	Seed yield (kg ha^{-1})	Harvest index	1000- seed weight (g)	MYMV reaction
6601-Check variety	1971	900	13.2	28	MS-S
NM 28[a]	1983	1050	15.0	30	MS-S
NM 13-1[a]	1986	1271	28.0	33	MS-S
NM 19-19[a]	//	1458	30.1	31	MS-S
NM 20-21[a]	//	1375	31.2	31	MS-S
NM 121-25[a]	//	1215	26.8	32	MS-S
NM 51[b]	1990	1536	30.6	45	MS-S
NM 54[b]	//	1517	25.9	54	MR-MS
NIAB MUNG 92c	1996	1811	37.0	52	Mod. Res
NIAB MUNG 98[c]	1998	1617	38.0	38	Mod. Res
NIAB MUNG 2006[c]	2006	1900	36.2	59	Resistant

a. Malik *et al*., 1986, b. Ashraf *et al*., 2001, c. Sadiq *et al*., 1999, 1999, 2006

Table 3. Rating used for scoring the incidence of MYMV.

Disease reaction	Percent infection	Disease score
Immune	No infection	1
Highly resistant	1-5 % infection	2
Resistant	6-10 % //	3
Moderately resistant	11-20 % //	4
Tolerant	21-30 % //	5
Moderately tolerant	31-40 % //	6
Moderately susceptible	41-50 % //	7
Susceptible	51-80 % //	8
Highly susceptible	81-100 % //	9

Table 4. Ratting used for scoring the incidence of CLS.

Disease reaction	Percent infection	Disease score
Immune	No lesions	1
Highly resistant	One spot per leaflet	2
Resistant	2-3 spots per leaflet	3
Moderately resistant	Spots covering 10-20% of leaflet area, no chlorosis	4
Tolerant	Spots covering 21-30% of leaflet area, no chlorosis	5
Moderately tolerant	Spots covering 21-30% of leaflet area, each spot surrounded by a chlorotic halo	6
Moderately susceptible	Spots covering 31-40% of leaflet area, entire leaf let mildly chlorotic	7
Susceptible	Spots covering 41-60% of leaflet area, entire leaflet severely chlorotic, abscission of one, two or three leaflets	8
Highly susceptible	Spots covering 61-100% of leaflet area, entire leaflet severely chlorotic, abscission of one, two or all of three leaflets	9

Results and Discussion

a. Improvement in yield potential: Mungbean improvement programme was initiated in 1975 at Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad to develop high yielding, short duration and disease resistant varieties to fit in different cropping systems. Two major types of local or desi mungbean available were i) photoperiod sensitive and ii) Photoperiod insensitive. The photoperiod sensitive "Desi mung" varieties were low yielding (250-500 kg ha^{-1}), asynchronous, and late maturing (95-115 days). They had spreading growth, small pods (5-6 cm), less number of seeds per pod (6-7 seeds per pod) and small seed size (20-25 g/1000 seeds). The colour of seed was usually green, either dull or shiny. Strong response of these varieties to day length forced farmers to postpone their sowing, which delayed the sowing of following wheat crop. They were susceptible to both mungbean yellow mosaic virus (MYMV) and *Cercospora* leaf spot (CLS) diseases. The photoperiod insensitive desi varieties gave relatively better yield (400-600 kg ha^{-1}). They had erect growth habit and took 90-95 days to mature in summer (kharif) and about 80 days in spring season. They had comparatively bigger pods (7-8 cm) and medium size (25-30 g/1000 seeds) with a green, but dull seed coat colour. They were, for the most part, also susceptible to MYMV and CLS (Ali *et al*., 1997, Ashraf *et al.*, 2001). The variety 6601 (land race) released by the Department of Agriculture, Punjab, in 1971, was in this category and remained the only approved variety of mungbean until 1983.

Long duration and non- synchronized maturity created strong competition with other crops for land and labour. Low yield eventually threw mungbean out of competition. Susceptibility of Var. 6601 to diseases made mungbean a risky crop, and its dull color made it unattractive to consumers. The challenge for researchers was to overcome these constraints and make mungbean an economically viable option for a wide range of cropping systems (Ali *et al*., 1997).

In the past, breeding work was limited to the selection from land races, which was mainly due to the scarcity of genetic variability in the local germplasm. Desirable genetic variability within the local germplasm was created through induced mutations, which resulted in the development of high yielding; small seeded and short duration varieties with high harvest index (Malik *et al*., 1986).

Hybridization between exotic and indigenous germplasm was initiated in 1980 to improve the yield potential through large seed size; an important seed yield component. F_1 were irradiated and top crosses were also tried to enhance genetic variability. There was a transgressive segregation for smaller seed size but no plants with seeds even as large as large seeded parent could be recovered in the F_2 and successive generations. Due to selection pressure for large seed size, the range of F_2 and F_3 progenies shifted towards the large seeded parent, indicating partial dominance of small seed size over large seed size. Large seeded selections were evolved through the accumulation of recessive genes with additive effects. The increase in seed yield was mainly due to an increase in harvest index and 1000 seed weight. The improvement culminated in the development of large seeded varieties with high yield potential *i.e*., NIAB MUNG 92, NIAB MUNG 98 and NIAB MUNG 2006 (Sadiq *et al.*, 1999a, 1999b, 1999c, 1999d, 1999e, 2006). The seed yield and other yield related traits of different mungbean varieties are shown in Table 2. Seed yield of large seeded varieties ranged from 1517 Kg ha^{-1} to 1900 Kg ha^{-1}, harvest index 25.9% to 38.0% and 1000 seed weight 45-59 gm. NIAB MUNG 2006 produced the highest seed yield of 1900 kg ha^{-1}, with a harvest index of 36.2 % and 59 gm 1000 seed weight. Development of high yielding, short duration and disease resistant varieties have been reported to have yield potential of 2.5 ton.ha^{-1} (Ali *et al*., 1997). Still there is large gap between the national yield and the realized yield. To bridge the gap, there is a need of development of high yielding, short duration varieties to fit in different cropping patterns, targeted production and dissemination of quality seed and transfer of efficient production and protection technology to the farmers. Vertical expansion in area approach seems difficult to work further. Horizontal expansion in area in different cropping systems has its advantages in term of production.

b. Improved disease resistance: Mungbean Yellow Mosaic Virus (MYMV), a white fly transmitted Gemini virus, causes one of the most serious diseases of mungbean in South Asia including Pakistan and is one of the most important constraints of mungbean production although no data indicating the extent of its incidence, severity and yield loss due to its infection is available in the country. The effect of disease varies with cultivar-to-cultivar is subjected to the genetic make up of the cultivar. The variety Mung Kabuli (highly susceptible to mungbean yellow mosaic virus) was repeatedly planted in all the segregating as well as true breeding germplasm as a spreader to intensify MYMV infection from natural source. The breeding material is kept unsprayed to maintain high population of the vector. Observations on MYMV infection were taken when 100% of the plants in the spreader line were infected with MYMV. Reaction to MYMV appears as bright yellow patches to complete yellowing of the leaves and other plant parts. The disease severity was scored on 0-9 scale based on visual symptoms as proposed by Shukla *et al*., 1978 (Table 3). They reported an involvement of two recessive genes for the control of MYMV. Tolerance/ susceptibility to MYMV were under the control of one major gene pair (Thakur *et al*., 1977). The disease reaction to MYMV of different varieties of mungbean at present is shown in Table 2. A new recently released variety NIAB MUNG 2006 has shown resistance against MYMV in addition to its high yield potential. It is expected that cultivation of this variety will enhance the farmer production in the country, thus curtailing the import bill.

References

Ali, M., I.A. Malik, H.M. Sabir and B. Ahmad. 1997. The Mungbean Green Revolution in Pakistan. *Technical Bulletin No. 24. AVRDC.* Shanhua, Taiwan, ROC. pp. 5.

Anonymous. 2004-05. *Agricultural Statistics of Pakistan*, Government of Pakistan, Ministry of Food, Agriculture and Livestock (Economic Wing), Islamabad. Pakistan.

Ashraf, M., P. Srinives, M.S. Sadiq and M. Saleem. 2001. AVRDC germplasm, its utilization and development of improved mungbean. *Pak. J. Bot*., 33: 443-452.

Boling, M., D.A. Sander and R.S. Matlock. 1961. Mungbean hybridization technique. *Agron. J*., 53: 54-55.

Malik, I.A., Y. Ali and G. Sarwar. 1986. Improvement of mungbean (*Vigna radiata* (L.) Wilczek and black gram (*Vigna mungo* (L.) Hepper) in yield, plant type and resistance to diseases through induced mutations. *Proceeding of the workshop on the improvement of grain legume production using induced mutations*. pp. 293-317.

Rachie, K.O. and L.M. Robert.1974. Grain legumes of the low land tropics. *Advances in Agronomy*, 26: 62-77.

Sadiq, M.S., G. Sarwar and G.S.S. Khattak. 1999a. NIAB MUNG 92: A high yielding and short duration mungbean variety. *Mutation Breeding Newsletter*, 44: 14 -15.

Sadiq, M.S., G. Sarwar and G.S.S. Khattak. 1999b. NIAB MUNG 98: A diverse, high yielding and disease resistant mungbean variety. *Pak. J. Biol. Sci*., 2(2): 455-458.

Sadiq, M.S., G. Sarwar, G.S.S. Khattak and M. Saleem. 1999c. Development of mungbean variety NIAB MUNG 98 involving induced mutants through conventional breeding. *Mutation Breeding Newsletter*, 44: 11-13.

Sadiq, M.S., G. Sarwar and G.S.S. Khattak. 1999d. Synthesis of mungbean germplasm with improved economic traits. *Pak. J. Biol. Sci*., 2(3): 962-966.

Sadiq, M.S., G. Sarwar, M. Saleem, G.S.S. Khattak, M. Ashraf and G. Abbas. 1999e. Breeding for improved seed yield in mungbean. *Pak. J. Biol. Sci*., 2(3): 988-990.

Sadiq, M.S., M. Saleem, S. Haidar and G. Abbas. 2006. NIAB MUNG 2006: A high yielding and disease resistant mungbean variety. *J. Agri. Res*., 44(2): 97-104.

Shukla, G.P., B.P. Pandya and D.P. Singh 1978. Inheritance of resistance to yellow mosaic in mungbean. *Ind. J. Genet. Plant Breed*., 38: 357-360.

Singh, V.P., A. Chhabra and R.P.S. Kharb. 1988. Production and utilization of mungbean in India. In: *Mungbean: proceeding of the second international symposium*. (Eds.): S. Shanmugasundaram and B.T. McLean. Shanhua, Taiwan, Asian Vegetable Research and Development Center, *AVRDC Publication* No. 88-304, pp. 486-497.

Steel, R.G.D. and J.H. Torrie. 1984. *Principles and Procedures of Statistics. A Biometrical Approach,* McGra Hill Book Co., New York, U.S.A.

Thakur, R.P., P.N. Patel and J.P. Verma. 1977. Genetical relationships between reaction to bacterial leaf spot, yellow mosaic and Cercospora leaf spot disease in mungbean (*Vigna radiata*). *Euphytica,* 26: 765-774.

Thirumaran, A.S. and M. A. Seralathan. 1988. Utilization of mungbean. In: *Mungbean: proceeding of the second international symposium*. (Eds.): S. Shanmugasundaram and B.T. McLean. Shanhua, Taiwan, Asian Vegetable Research and Development Center, *AVRDC Publication* No. 88-304, pp. 470-485.

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