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BREEDING FOR HEAT TOLERANCE IN MUNGBEAN (*VIGNA RADIATA* (L.) WILCZEK)

GUL SANAT SHAH KHATTAK*, IQBAL SAEED AND TILA MUHAMMAD

Nuclear Institute for Food and Agriculture (NIFA), Peshawar, NWFP, P. O. Box 446, Pakistan

Abstract

14 commercial mungbean varieties and 24 advanced genotypes developed through hybridization were evaluated for maximum flowers' retention capability under high temperature (above 40°C) and agronomic traits at NIFA, Peshawar during summer (15th March - June) 2005. Similarly 77 mutants derived from NM 92 and 51 recombinants selected from three crosses i.e. VC1560D x NM92, VC1482C x NM92 and NM98 x VC3902A were evaluated for maximum flowers' retention capability under high temperature and agronomic traits at NIFA, Peshawar during summer 2006. Almost all of the commercial varieties and advanced genotypes showed moderate tolerance to flowers' shedding under high temperature except NM 92 which showed susceptibility to flowers' shedding under high temperature. The mutants derived from NM92 and recombinants selected from the three crosses showed moderate tolerance to flowers' shedding under high temperature. The commercial varieties and advanced genotypes differed significantly for days to50% flowering, days to 90% pods maturity, plant height, 1000 seed weight and seed yield/plant. NFM-6-5 and NFM-12-14 showed significantly high seed yield as compared to NM 92. No genotype among the evaluated material showed absolute tolerance to flowers' shedding while NM 92 showed susceptibility to the same trait under high temperature (above 40°C).

Key words: Flower retention, flower shedding, heat tolerance, heat susceptibility, mungbean

Introduction

Mungbean has been major kharif (July - October) pulse crop of Pakistan grown in rotation with wheat but now the farmers are shifting its sowing from July to June in Punjab province whereas in NWFP, mungbean sowing starts from mid May. The main reason for early sowing is the environmental change that results in poor grain development in pods ultimately leading to an overall reduction in seed yield. The second important factor for the shift in sowing is high price for an early produce in the market.

The severe problem faced by the mungbean growers due to shifting mungbean sowing from July to May/June is the high temperature (above 40^0C) during May, June and July, which causes drastic reduction in seed yield due to high or otherwise complete flowers' shedding. Rainey & Griffiths (2005) reported abscission of reproductive organs as the primary determinant of yield under heat stress in many annual grain legumes.

In mungbean, flowers are borne in clusters of 10 to 20 in axillary or terminal racemes and come in different flushes. Flowers' shedding is very common in this crop and the extent of flowers' shedding has been reported up to 79 percent (Kumari & Varma, 1983). Flowers' shedding in mungbean and chickpea increases under high temperature, precipitation, and desiccating winds during the flowering period (Tickoo *et al*., 1996; Sinha, 1977). Mungbean thrives best in temperature 30^0C to 40^0C but above 40^0C, there is a significant flower shedding (Tickoo *et al*., 1996). Screening and selection

* Corresponding author: Gul Sanat Shah Khattak; gssktt@yahoo.com

of mungbean genotypes, which can retain maximum number of flowers and produce productive pods during high temperature (above 40^0C), are essential to increase its production in the country. Meagre basic information are available about mungbean flower shedding and no research work has been carried out for breeding of mungbean for maximum flowers' retention capability under high temperature (above 40^0C). In wheat heat tolerant genotypes have been developed and reported by researchers (Dhanda & Munjal, 2006; Tahir *et al.* 2006).

Evaluation of mungbean genotypes under high temperature in field condition and creation of genetic variability for flowers' thermo-sensitivity through hybridization and induced mutations have been described in this paper.

Materials and Methods

14 mungbean varieties evolved in the country and 24 advanced genotypes developed at NIFA through hybridization were evaluated for flowers' retention capability and agronomic traits in randomized complete block design with three replications and plant-to-plant and row-to-row spacing of 10 cm and 30 cm, respectively at NIFA, Peshawar during summer (15^{th} March-June) 2005. Row length kept 4 m and each plot in each replication was consisted of 4 rows. Ten randomly selected plants per replication were used to record the desired data. A high yielding but sensitive to flowers' shedding during high temperature (above 40^0C) mungbean variety, NM 92, was used to induce genetic variability for maximum flower retention capability during high temperature through induced mutation. Seeds of NM 92 were irradiated at 0.20, 0.30 and 0.40 KGy doses of gamma rays using ^{60}Co gamma cell and raised M_1 generation at NIFA during Kharif 2004. All M_1 plants were harvested individually and planted as plant progeny rows in M_2 population along with parent during summer 2005. Single plants were selected in M_2 populations on the basis of no or fewer flowers shedding from the terminal raceme on main stem. M_3 and M_4 generations of no or low flowers' shedding mutants were raised as line-progeny-rows along with parent to confirm and evaluate the desired breeding behavior of selected mutants during kharif 2005 and summer 2006, respectively.

Similarly, three crosses i.e. VC 1560D x NM 92, VC 1482C x NM 92 and NM 98 x VC 3902A were attempted during summer 2004 and F_1 was raised during kharif 2004. The hybrid plants were picked individually and planted as plant-progeny in F_2 generation along with NM 92. Single plants were selected in F_2 populations on the basis of no or low flower shedding from the terminal raceme on main stem. F_3 and F_4 generations of no or fewer flowers' shedding recombinants were raised as line-progeny-rows along with NM 92 to confirm and evaluate the desired breeding behavior of the selected lines during kharif 2005 and summer 2006, respectively. Each mutant/recombinant line was planted in 4m long rows with plant-to-plant and row-to-row spacing of 10cm and 30cm, respectively. Ten plants were randomly selected from each mutant/recombinant line to record desired data. The data recorded from replicated trials and non-replicated mutant/recombinant lines were as bellow:

Days to flowering: Average days of 10 randomly selected plants counted from sowing to the initiation of first flower.

Days to maturity: Average days of 10 randomly selected plants counted from sowing to 90% pods maturity.

Plant height (cm): Average height of 10 randomly selected plants recorded from the base of plant to the top peduncle on the main branch.

1000 seed weight (g): Average weight of three random samples of 1000 seed from a genotype.

Seed yield plant^{-1} (g): Average seed weight of 10 randomly selected plants.

Flowers thermo sensitivity rating: Average flower shedding (%) from the terminal raceme on the main stem of 10 randomly selected plants. Ratings for tolerant, moderately tolerant and susceptible genotype were made as follow:

Flowers shedding (%)	Rating
10-20	Tolerant
20-40	Moderate tolerant
>40	Susceptible

Replicated trails data were analyzed for Analysis of Variance (ANOVA) according to Steel & Torrie (1980).

Results

All the genotypes evaluated in replicated yield trials during summer 2005 showed significant variation for days to flowering and maturity, plant height, 1000 seed weight and seed yield per plant (Table 1 & 2). The flower thermo sensitivity rating of the genotypes evaluated in these trials showed lack of absolute tolerance to high temperature (above 40^{0}C). Most of the genotypes showed moderate tolerance to high temperature during flowering period. NM 92 showed susceptibility to high temperature. During summer 2005, temperature rose above 40^{0}C during the month of June, therefore, the last flower flush was affected and flowers' shedding was observed only during the last flower flush.

Mutants derived from NM 92 and recombinants selected from VC 1560D x NM 92, VC 1482C x NM 92 and NM 98 x VC 3902A were evaluated for heat tolerance and other agronomic traits as line progeny rows during summer 2006 (Table 3 & 4). None of the genotypes showed tolerance to high temperature. Most of the genotypes showed moderate tolerance to high temperature as compared to the susceptible variety NM 92. Temperature above 40^{0}C was observed in May and the last week of June during summer 2006, therefore, crop flowering was affected to some extent at first flush and completely at second flush.

Table 1: Evaluation of mungbean-advanced lines during summer 2005 at NIFA, Peshawar

Genotype	Parentage	Days to flowering (50%)	Days to maturity (90%)	Plant height (cm)	1000-seed weight (g)	Seed yield per plant (g)	Flowers thermo sensitivity rating
NFM 14-12	NM 92 x Pusa Baisakhi	56	80	63	50	10	MT
NFM 12-8	VC1482C x NM92	43	80	50	49	10	MT
NFM 12-5	VC1482C x NM92	41	81	56	55	10	S
NFM 13-1	6601 x NM 92	44	80	50	52	11	MT
NFM 14-5	NM 92 x Pusa Baisakhi	55	85	53	45	12	MT
NFM 12-15	VC1482C x NM92	42	75	51	54	11	MT
NFM 13-2	6601 x NM 92	44	76	56	55	12	MT
NFM 13-8	6601 x NM 92	60	82	56	45	12	MT
NFM 6-1	VC 1971A x NM 92	58	81	35	56	12	MT
NFM 7-13	VC 1560D x NM 92	43	80	40	54	10	MT
NFM 3-3	VC 3726 x NM 36	42	85	57	55	11	MT
NFM 11-4	NM 92 x Blackmung	44	84	54	52	12	MT
NFM 6-5	VC 1971A x NM 92	39	80	47	55	14	MT
NFM 12-14	VC1482C x NM92	59	75	66	50	13	MT
NFM 8-1	NM 93 x NM 92	43	70	54	56	11	MT
NFM 11-3	NM 92 x Blackmung	44	68	58	55	12	MT
NFM 7-3	VC 1560D x NM 92	41	65	52	54	11	MT
NFM 8-22	NM 93 x NM 92	46	70	58	56	12	MT
NFM 12-6	VC1482C x NM92	41	80	57	54	11	MT
NFM 8-2	NM 93 x NM 92	44	65	56	48	12	MT
NFM 14-3	NM 92 x Pusa Baisakhi	39	75	50	47	11	S
NFM 14-7	NM 92 x Pusa Baisakhi	56	60	55	50	11	MT
NFM 7-6	VC 1560D x NM 92	43	63	53	51	11	MT
NFM 14-6	NM 92 x Pusa Baisakhi	56	67	56	50	11	MT
NM 92	NM 36 x VC 2768B	37	79	53	51	9	S
SE		1.5	2.0	1.5	1.5	1.5	
LSD (5%)		3.5	6.0	4.5	3.0	3.5	

Table 2: Evaluation of mungbean genotypes during summer 2005 at NIFA, Peshawar

Genotype	Evolving institute	Days to flowering (50%)	Days to maturity (90%)	Plant height (cm)	1000-seed weight (g)	Seed yield per plant (g)	Flowers thermo sensitivity rating
6601	AARI, Faisalabad	56	70	90	31	10	MT
NM 28	NIAB, Faisalabad	53	72	80	30	9	MT
NM 13-1	NIAB, Faisalabad	39	78	66	34	9	MT
NM 19-19	NIAB, Faisalabad	37	80	63	31	9	MT
NM 20-21	NIAB, Faisalabad	39	76	64	35	10	MT
NM 121-25	NIAB, Faisalabad	54	81	90	30	10	MT
NM 51	NIAB, Faisalabad	44	79	74	39	10	MT
NM 54	NIAB, Faisalabad	40	80	75	54	10	MT
Mung-88	ARS, Bahawalpur	52	80	98	28	8	MT
Chakwal-97	ARS, Chakwal	50	81	91	29	8	MT
AEM-96	NIA, Tandojam	53	75	95	29	9	MT
Karak mung	ARS, Karak	37	75	86	37	8	MT
NM 98	NIAB, Faisalabad	41	71	75	39	11	MT
NM 92	NIAB, Faisalabad	38	74	80	50	10	S
SE		1.5	1.5	3.5	1.5	1.0	
LSD (5%)		3.0	3.5	6.0	2.5	3.0	

Table 3: Evaluation of mungbean advanced mutants as line progeny rows during summer 2006 at NIFA, Peshawar

Mutant	Parentage	Days to flowering (50%)	Days to maturity (90%)	Plant height (cm)	1000-seed weight (g)	Seed yield per plant (g)	Flower thermo sensitivity rating
20-1	NM92 irradiated at 0.2 KGy	46	71	52	49	7	MT
20-2	-do-	46	71	51	48	6	MT
20-3	-do-	48	70	55	54	7	MT
20-4	-do-	46	70	50	58	7	S
20-5	-do-	46	71	50	58	6	MT
20-6	-do-	46	75	50	58	6	MT
20-7	-do-	46	72	51	58	8	MT
20-8	-do-	46	75	50	56	7	MT
20-9	-do-	46	73	51	50	6	MT
20-10	-do-	46	75	50	55	8	MT
20-11	-do-	46	73	54	54	7	MT
20-12	-do-	46	73	52	53	6	MT
20-13	-do-	46	73	51	55	6	MT
20-14	-do-	46	75	53	52	9	MT
20-15	-do-	46	74	57	50	9	MT
20-16	-do-	46	72	52	51	7	MT
20-17	-do-	46	74	53	55	7	MT
20-18	-do-	46	75	54	52	7	MT
20-19	-do-	46	74	52	54	8	MT
20-20	-do-	47	72	56	54	10	MT
20-21	-do-	46	73	52	58	10	MT

Cont. Table-3

20-22	-do-	46	74	53	50	8	S
20-23	-do-	46	75	52	55	9	MT
20-24	-do-	46	75	51	53	9	MT
20-25	-do-	46	72	53	55	10	MT
20-26	-do-	46	72	56	56	9	S
20-27	-do-	46	73	52	54	9	MT
20-28	-do-	47	75	52	54	11	MT
20-29	-do-	46	72	53	55	8	MT
20-30	-do-	46	71	52	51	9	MT
20-31	-do-	46	75	55	52	10	MT
20-32	-do-	46	71	53	58	12	MT
20-33	-do-	46	70	58	50	8	MT
20-34	-do-	46	71	55	50	11	MT
20-35	-do-	47	71	54	49	10	MT
20-36	-do-	47	71	64	52	8	MT
20-37	-do-	46	72	54	54	9	MT
20-38	-do-	46	71	55	55	8	MT
20-39	-do-	47	72	51	53	9	MT
30-1	NM92 irradiated at 0.3 KGy	48	71	55	55	6	S
30-2	-do-	46	72	60	58	8	MT
30-3	-do-	46	70	56	54	7	MT
30-4	-do-	46	75	58	52	8	MT
30-5	-do-	47	71	52	58	8	MT
30-6	-do-	47	71	55	58	7	MT
30-7	-do-	47	70	53	58	6	MT
30-8	-do-	48	71	51	54	6	MT
30-9	-do-	46	70	50	51	6	MT
30-10	-do-	46	71	56	58	7	MT
30-11	-do-	46	69	59	54	6	MT
30-12	-do-	46	69	65	50	6	MT
30-13	-do-	47	69	60	50	8	MT
30-14	-do-	46	69	56	58	6	MT

Cont. Table-3

30-15	-do-	47	71	58	52	6	MT
30-16	-do-	47	69	57	50	7	MT
30-17	-do-	47	71	59	58	7	MT
30-18	-do-	47	70	56	56	6	MT
40-1	NM92 irradiated at 0.4 KGy	46	75	61	54	9	MT
40-2	-do-	46	73	57	48	9	S
40-3	-do-	48	69	55	48	9	MT
40-4	-do-	48	72	54	54	9	MT
40-5	-do-	47	75	50	54	9	MT
40-6	-do-	47	75	65	58	8	MT
40-7	-do-	47	80	58	49	8	MT
40-8	-do-	46	78	53	50	10	MT
40-9	-do-	46	73	52	55	8	MT
40-10	-do-	46	75	50	56	9	S
40-11	-do-	47	75	52	52	10	MT
40-12	-do-	46	72	50	52	10	MT
40-13	-do-	46	75	50	55	11	MT
40-14	-do-	46	76	50	54	9	S
40-15	-do-	46	80	50	54	9	MT
40-16	-do-	47	81	50	54	9	MT
40-17	-do-	47	75	51	56	10	MT
40-18	-do-	47	75	52	54	9	MT
40-19	-do-	47	73	50	50	8	MT
40-20	-do-	46	73	50	51	9	S
NM92	Parent	45	71	55	52	8	S

Table 4: Evaluation of mungbean advanced lines as line progeny rows during summer 2006 at NIFA, Peshawar

Genotype	Parentage	Days to flowering (50%)	Days to maturity (90%)	Plant height (cm)	1000-seed weight (g)	Seed yield per plant (g)	Flower thermo sensitivity rating
5-36-1	VC 1560D x NM 92	49	84	63	59	7	MT
5-36-3	-do-	46	85	50	52	8	MT
5-36-4	-do-	46	85	51	55	6	MT
5-36-5	-do-	48	86	52	52	8	S
5-36-6	-do-	48	86	63	56	7	MT
5-36-8	-do-	46	76	52	55	8	MT
5-36-11	-do-	48	85	53	54	7	MT
5-36-15	-do-	48	85	56	53	7	MT
5-36-24	-do-	49	84	56	54	8	MT
5-36-26	-do-	49	86	53	55	8	MT
5-36-29	-do-	47	85	58	55	7	MT
5-36-30	-do-	48	85	56	48	8	MT
5-36-31	-do-	48	84	60	54	7	MT
5-36-33	-do-	49	76	67	56	8	MT
5-36-41	-do-	48	74	65	55	7	MT
5-36-43	-do-	48	75	67	54	7	MT
5-36-45	-do-	48	75	63	58	7	MT
5-63-26	VC1482C x M92	46	75	54	54	6	MT
5-63-28	-do-	46	74	54	55	7	S
5-63-29	-do-	46	80	52	55	7	MT
5-63-30	-do-	46	80	54	56	6	MT
5-63-33	-do-	46	82	53	54	9	MT
5-63-35	-do-	46	83	55	56	10	MT
5-63-39	-do-	46	83	50	50	6	MT

Cont. Table-4

5-63-42	-do-	48	84	61	51	7	MT
5-63-45	-do-	48	84	51	52	7	MT
5-63-48	-do-	48	84	50	55	6	MT
5-63-49	-do-	48	84	55	53	8	MT
5-63-51	-do-	46	85	51	49	7	MT
5-63-57	-do-	49	83	50	50	7	MT
5-91-7	NM 98 x VC3902A	48	80	60	51	7	MT
5-91-9	-do-	49	78	57	57	7	MT
5-91-10	-do-	46	81	53	50	8	MT
5-91-12	-do-	48	81	52	58	7	MT
5-91-15	-do-	46	84	55	53	8	S
5-91-16	-do-	46	83	54	56	6	MT
5-91-17	-do-	46	84	59	53	7	MT
5-91-19	-do-	48	76	57	48	8	MT
5-91-20	-do-	46	82	62	52	9	MT
5-91-21	-do-	46	80	51	55	8	MT
5-91-22	-do-	46	81	54	54	7	MT
5-91-23	-do-	46	80	56	50	8	MT
5-91-24	-do-	46	80	57	53	7	S
5-91-26	-do-	46	79	55	55	7	MT
5-91-28	-do-	48	76	56	58	7	MT
5-91-29	-do-	46	80	57	56	7	MT
5-91-30	-do-	46	81	55	55	7	MT
5-91-31	-do-	46	84	54	52	8	MT
5-91-33	-do-	48	85	59	50	8	MT
5-91-34	-do-	46	85	57	55	9	MT
5-91-35	-do-	46	84	57	54	7	MT
NM 92	Parent	46	70	57	51	7	S

Discussion

Precipitation, and desiccating winds are the physical causes of flower shedding in mungbean but high temperature may shed flowers due to some hormonal changes or failure in fertilization. The failure in hybridization could be due to the indehiscence of anthers during night or because of drying up of stigma and ovary of the flower due to high temperature during the day. Failure in hybridization due to the indehiscence of anthers during night due to high temperature in cowpea and drying up of stigma and ovary of the flower in mungbean due to high temperature during day have already been reported by Khattak *et al*. (1998).

It has also been observed during the current study that genotypes with more synchrony in pods maturity were prone to more flower shedding compared to the genotypes having uneven maturity behaviour. For synchrony in pods maturity, the genotype has to produce more flowers in a short period of time and should take very short interval between the flushes. Thus, under same high temperature environment, more flowers will be available to be affected by high temperature on more synchronous genotypes compared to less synchronous, which is purely the escape mechanism of flowers from high temperature during flowering stages. No genetically tolerant genotype was found in the evaluated germplasm to flower thermo sensitivity during high temperature. Similarly, genotypic differences for number of flowers produced in mungbean have also been reported by the earlier researchers (AVRDC, 1976; Kumari & Verma, 1983).

Segregating material generated through induced mutation by irradiating NM 92 and hybridization among VC 1560D x NM 92, VC 1482C x NM 92 and NM 98 x VC 3902A were screened and selections for high pod-setting and low flower shedding under high temperature in field conditions were made by selecting single plants in each segregating generation. The selected advanced mutants and recombinants lines showed moderate tolerance to flower shedding under high temperature. A cowpea commercial variety has been developed through pedigree breeding programme by Ehlers *et al*. (2000).

Conclusion:

Both number of flowers produced and percent flowers' shedding by a genotype under high temperature environment are important selection criteria for selecting mungbean genotypes tolerant to flower shedding but the critical factor is the number of flowers retained by the genotype and developed in to mature pods. It is a practical approach to develop a genotype, which may produce high yield under high temperature. The available mungbean germplasm lack tolerance to flowers' retention under high temperature (above 40^0C). The induction of thermo tolerance in high yielding genotypes will be a great genetic breakthrough to increase mungbean production in the country.

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