Pak. J. Bot., 37(2): 279-284, 2005.

EVALUATION OF HIGH YIELDING MUTANTS OF *BRASSICA JUNCEA* CV. S-9 DEVELOPED THROUGH GAMMA RAYS AND EMS

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Abstract

Homogeneous seeds of *Brassica juncea* L. cv. S-9 were treated with different doses of gamma rays (750 and 1000 Gy) and EMS (0.75% and 1.0%) to induce genetic variability for the selection of genotypes with improved quantitative and quality traits. After passing through different stages of selection, 17 promising mutants were selected for further studies. Seventeen mutants and its parent were evaluated for yield and yield components in the preliminary yield trials for two consecutive years. Three mutants S 97-75/36, S 97-1.0E/20 and S 97-1.0E/21 were significantly ($p \leq 0.05$) superior to all other entries in grain yield and these were also found early in maturity, short statured and having high seed index.

Introduction

Brassica juncea L., (2n=AABB=36) is the most common source of edible oil in many Afro-Asian countries. This is an amphidiploid as well as allopolyploid, originated through natural crossing between *B. nigra* (2n =BB =16) and *B. campestris* (2n=AA=20) (Larik & Hussain, 1990). Pakistan is overwhelmingly an agrarian economy, but is unable to produce edible oils sufficient for domestic requirements hence a substantial amount of foreign exchange is spent on its import. In consequence, there is about 3-4% increase in the import bill of edible oil every year. To save an average outflow of foreign exchange of about $ 700 million on import of edible oils annually, concentrated efforts are needed to increase the local production of oilseeds (Rizvi, 2001).

Oleiferous Brassica (rapeseed and mustard) has been an important conventional oilseed crop of the sub-continent. In Pakistan, it is grown over an area of 272100 ha, but its production per unit area is very low i.e., 836 kg ha^{-1} (Anon., 2002). There are many factors responsible for its low yield, but the most important one is the non availability of high yielding varieties. It is, therefore, imperative to develop improved varieties of oilseed Brassica to bridge the gap between local production and import of edible oil in the country.

Availability of genetic variability is the prerequisite for any breeding programme. Besides conventional methods, induced mutation has been extensively used for creating new genetic variation in crop plants. Literature revealed that more than 2200 mutant varieties of different crops with improved agronomic traits have been developed and released to the farmers for general cultivation all over the world (Maluszynski *et al*., 2000). Mutagenesis technique has also been successfully employed in rapeseed and mustard by the plant breeders (Naz & Islam 1979; Javed *et al*., 2000) to alter the genetic architecture of plant and isolate the possible mutants with desired economic plant characters such as plant height, number of pods per plant, number of grain per pod, 1000-grain weight, grain yield, oil content and disease resistance (Rehman *et al.*, 1987; Robbelen, 1990; Mahla e*t al.*, 1990, 1991; Rehman, 1996; Shah *et al.*, 1990, 1998, 1999; Javed *et al*., 2000).

The present study was therefore carried out to evaluate the performance of newly developed mutants of *Brassica juncea* L. cv. S-9 for yield and yield components under agroclimatic conditions of Tandojam, Sindh, Pakistan.

Materials and Methods

The research work was conducted at the Nuclear Institute of Agriculture, Tandojam for two consecutive years i.e. 2000-2001 and 2001-2002. Pure and uniform seeds (dry) of *Brassica juncea* L. cv. S-9 were irradiated with 750 and 1000 Gy of gamma rays from Cesium-137 (Cs^{137}) at the dose rate of 30.80 Gy per minute. Pure and uniform seeds (wet) with 16 hour pre-soaking time were then treated with EMS (3-4 hours), with a dose range of 0.75% and 1.00% and a thorough post washing with distilled water was done for 2-3 hours, to induce genetic variability for the selection of improved genotypes. The irradiated seeds alongwith non-irradiated (control) were sown in the field to raise M_1 generation. At maturity, 5 pods from each terminal and primary racemes of each plant were harvested and seeds were bulked dose-wise to raise M_2 generation. Selections for the desired quantitative traits were carried out in different growth stages. Of the hundreds of mutated population, 17 mutants were selected on the basis of their promising performance for grain yield and agronomic traits.

Seventeen promising mutants along with parent variety S-9 were evaluated in preliminary yield trial in RCBD design with three replicates, each plot consisted of four-meter long five rows 45 cm apart. Ten plants were selected at random from each plot to record the data on yield and yield components for biometrical analysis, while three central rows were harvested to estimate yield per unit area. Oil was determined by Soxtec apparatus. The data were analyzed statistically according to Gomez & Gomez (1984) and the mean values were compared by DMR test at 5% level of significance.

Results and Discussion

Quantitative traits: Significant ($p \leq 0.05$) differences were observed amongst all the entries for the quantitative traits under evaluation. All the mutants were found at par with each other in stature but significantly shorter than parent S-9. Mutant strain S 97-1.0E/21 took 112.7 days to mature followed by S 97-75/36 (115 days) and S 97-1.0E/20 (116 days) matured earlier. The parent S-9 was last to mature and required almost 118.3 days during 2000-01 (Table 1). More or less similar trend was observed in subsequent year (Table 2) and pooled data over the years (Table 3).

The mutants S 97-1.0E/21 (183.8 cm) and S 97-75/36 (184.6 cm) were observed as short stature than the parent S-9 (198.9 cm) (Table 1). Both the mutants maintained their superiority in the subsequent year 2001-02 and pooled data over the years (Table 2 & 3). Tall varieties of oleiferous brassica often lodge and potential yield were rare to be achieved. Plants with shorter plant height usually produce higher grain yield because of good response to higher doses of fertilizer and tolerance to lodging even under unfavourable weather conditions. Moreover, the dwarfness in plant height is associated with earliness in maturity (Olejniczak & Adamska, 1999), which is a desirable character in crop plants. Chauhan & Kumar (1986), Das & Rahman (1988, 1994) and Shah *et al.* (1990) have isolated short statured mutants with high yield potential from mutagen treated populations of rapeseed and mustard. This confirmed that induced mutation through gamma rays and EMS have played a significant role in the alteration of plant architecture and selection of mutants with enhanced yield potential in rapeseed and mustard (Rahman, 1996; Shah *et al*., 1999).

Table 1. Performance of S-9 mutant strains in preliminary yield trial during 2000-2001.

Mutants	Maturity (days)	Plant height (cm)	1000 grain Wt. (g)	Grain yield Kg/ha	Oil content %
S-9(P)	118.3 ABC	198.9 ABCD	3.52 E	756.2 K	35.67 BCDEF
S 97-1.0E/20	**116.0 BC**	**190.9 DEFG**	**3.97 AB**	**1527 C**	**38.83 AB**
S 97-1.0E/21	**112.7 D**	**183.8 H**	**3.99 AB**	**1671 B**	**38.00 AB**
S 97-1.0E/22	120.3 AB	202.9 AB	3.65 DE	1113. HIJ	32.42 EFG
S 97-75/29	117.0 BC	189.3 EFG	3.89 ABCD	1407 CDE	33.42 CDEFG
S 97-75/33	117.7 ABC	193.3 DEFG	3.99 AB	1162 GHI	33.58 CDEFG
S 97-75/35	117.7 ABC	189.5 DEFG	3.82 BCD	1375 DE	33.58 CDEFG
S 97-75/36	**115.0 CD**	**184.6 H**	**4.10 A**	**1813 A**	**37.00 ABC**
S 97-100/45	120.3 AB	184.9 GH	3.85 ABCD	1029 IJ	31.75 FG
S 97-100/46	117.0 BC	197.5 BCDE	3.78 BCD	1419 CD	32.75 DEFG
S 97-100/48	117.0 BC	190.6 DEFG	3.72 BCDE	1159 GHI	31.25 G
S 97-0.75+75/50	117.7 ABC	187.5 FGH	3.92 ABC	1314 DEF	36.42 ABCDE
S 97-0.75+75/55	120.3 AB	194.1 BCDEFG	3.96 AB	1161 GHI	36.99 ABCD
S 97-0.75+75/57	121.0 AB	198.4 ABCDE	3.77 BCD	1069 HIJ	32.67 DEFG
S 97-0.75+75/62	120.7 AB	192.7 CDEFG	3.78 BCD	1265 EFG	35.92 BCDE
S 97-1.00+75/60	120.3 AB	200.9 ABC	3.85 ABCD	1211 FGH	40.00 A
S 97-1.00+75/61	119.3 ABC	206.6 A	3.93 AB	973.5 J	36.90 ABCD
S 97-1.00+100/65	119.3 ABC	184.7 H	3.66 CDE	1386 CDE	36.58 ABCD

DMR test (0.05): Means followed by the same letters are not significantly different from each other.

Table 2. Performance of S-9 mutant strains in preliminary yield trial during 2001-2002.

Mutants	Maturity (days)	Plant height (cm)	1000 grain Wt. (g)	Grain yield Kg/ha	Oil content %
S-9(P)	129.00 A	198.20 AB	2.82 CD	1442 BC	28.58 D
S 97-1.0E/20	**122.00 BC**	**191.50 ABC**	**3.85 A**	**1559 ABC**	**31.62 A**
S 97-1.0E/21	**120.00 C**	**180.00 C**	**3.88 A**	**1692 A**	**31.58 AB**
S 97-1.0E/22	126.00 AB	189.10 ABC	3.38 B	1025 E	30.75 ABC
S 97-75/29	120.70 C	195.10 ABC	3.24 BCD	1129 E	29.33 CD
S 97-75/33	122.00 BC	194.50 ABC	3.68 AB	1419 BC	31.00 ABC
S 97-75/35	123.30 BC	193.60 ABC	3.38 B	1174 DE	29.50 CD
S 97-75/36	**120.70 C**	**184.8 BC**	**3.92 A**	**1612 AB**	**31.45 AB**
S 97-100/45	120.70 C	200.10 A	2.86 CD	1388 BCD	30.75 ABC
S 97-100/46	123.70 BC	193.00 ABC	2.88 CD	1021 E	30.08 BCD
S 97-100/48	125.30 AB	188.50 BC	3.18 BCD	421.8 F	30.17ABCD
S 97-0.75+75/50	122.00 BC	186.50 BC	3.17 BCD	1101 E	30.42 ABC
S 97-0.75+75/55	124.00 BC	206.70 A	2.80 CD	1179 DE	29.83 BCD
S 97-0.75+75/57	124.70 BC	206.70 A	2.75 D	1531 ABC	29.50 CD
S 97-0.75+75/62	124.30 BC	205.00 A	2.89 CD	1076 E	31.42 AB
S 97-1.00+75/60	123.00 BC	191.10 ABC	3.22 BCD	1500 ABC	31.67 A
S 97-1.00+75/61	125.70 AB	205.90 A	3.13 BCD	313.3 F	30.17ABCD
S 97-1.00+100/65	124.70 BC	188.50 BC	3.15 BCD	1371 CD	30.83 ABC

DMR test (0.05): Means followed by the same letters are not significantly different from each other.

Table 3. Pooled performance of S-9 mutant strains in preliminary yield Trial from 2000-2001 to 2001-2002.

Mutants	Maturity (days)	Plant height (cm)	1000 grain Wt. (g)	Grain yield Kg/ha	Oil content %
S-9(P)	123.65 A	198.55 ABC	3.17 E	1099 D	32.12 CD
S 97-1.0E/20	**119.00 CDE**	**191.20 BCDE**	**3.91 A**	**1543 AB**	**35.23 A**
S 97-1.0E/21	**116.35 E**	**181.90 E**	**3.93 A**	**1681 AB**	**34.79 AB**
S 97-1.0E/22	123.15 AB	196.00 ABCD	3.51 BCD	1069 D	31.58 CD
S 97-75/29	118.85 CDE	192.20 BCD	3.56 BCD	1268 CD	31.37 CD
S 97-75/33	119.85 BCD	193.90 BCD	3.83 A	1290 CD	32.29 CD
S 97-75/35	120.5 ABCD	191.55 BCD	3.60 ABC	1274 CD	31.54 CD
S 97-75/36	**117.85 DE**	**184.70 DE**	**4.01 A**	**1712 A**	**34.23 BC**
S 97-100/45	120.52 ABCD	192.50 BCD	3.35 CDE	1208 CD	31.25 CD
S 97-100/46	120.35 ABCD	195.25 ABCD	3.33 CDE	1220 CD	31.41 CD
S 97-100/48	121.15 ABCD	189.55 DE	3.45 BCDE	790.4 D	30.71 D
S 97-0.75+75/50	119.85 BCD	187.00 DE	3.54 BCD	1207 CD	33.42 BC
S 97-0.75+75/55	122.15 ABC	200.40 ABC	3.38 BCDE	1170 CD	33.41 BC
S 97-0.75+75/57	122.85 AB	202.55 AB	3.26 DE	1300 BC	31.08 CD
S 97-0.75+75/62	122.5 ABC	198.85 ABC	3.33 CDE	1170 CD	33.67 BC
S 97-1.00+75/60	121.65 ABC	196.00 ABCD	3.53 BCD	1355 BC	35.84 A
S 97-1.00+75/61	122.50 ABC	205.90 A	3.53 BCD	643 E	33.54 BC
S 97-1.00+100/65	122.00 ABC	186.60 DE	3.40 BCDE	1378 BC	33.70 BC

DMR test (0.05): Means followed by the same letters are not significantly different from each other.

All the genotypes were significantly superior or at par with parent S-9 in 1000 grain weight. Highest seed index was observed in S 97-75/36 (4.10 and 3.92) followed by S 97-1.0E/21 (3.99 & 3.88) and S 97-1.0E/20 (3.97 & 3.85) than the remaining entries (Table 1 & 2). Pooled data also revealed that they have bold seed because of the highest 1000-grain weight than all the entries (Table 3). These mutants exhibited higher 1000-grain weight than the parent S-9, which probably indicates an increase in the size of grain as a result of induced mutation. The result is in conformity with the findings of Chauhan & Kumar (1986) and Shah *et al*., (1990), who have also reported the bold-seeded mutants in oilseed Brassica.

Breeding for high yield is essentially based on the generation of new genotypes with improved yield and yield components or better agronomic traits, which are responsible for substantial increase in yield. All the mutants were significantly ($p \leq 0.05$) superior to the parent in grain yield (kg ha^{-1}) during 2000-2001 (Table 1). The mutant S 97-1.0E/21 ceded significantly maximum grain kg ha^{-1} (1692), followed by S 97-75/36 (1612) and S 97-1.0E/20 (1559) as compared with all other genotypes during 2001-2002 (Table 2). Maximum grain yield (kg ha^{-1}) was achieved in mutant strains S 97-75/36 (1712) and S 97-1.0E/21 (1681), followed by S 97-1.0E/20 (1543) over the years (Table 3).

Quality traits: Oil content is a primary and an important component of oilseed crops. Of all the genotypes under evaluation, the highest oil content was produced by S 97-1.00+75/60 (40%) followed by S 97-1.0E/20 (38.83), S 97-1.0E/21 (38.00) and S 97-75/36 (37.00) during 2000-2001 (Table 1). These mutants maintained their superiority during 2001-2002 (Table 2) and pooled over the years (Table 3), respectively. However, the mutant strain S 97-1.00+75/60 ceded high oil content, but produced lower grain yield kg ha^{-1} (1211) on the contrary S 97-75/36 (1813), S 97-1.0E/20 (1671) and S 97-1.0E/21 (1527) produced higher grain yield during 2000-01 (Table 1). Similar results were observed during 2001-02 and pooled over the years (Table 2 & 3).

Table 4. Correlation coefficient 'r' among 5 characters in oleiferous Brassica.

	Maturity (days)	**Plant height (cm)**	**1000 Grain wt. (g)**	**Grain yield Kg/ha**
Plant height (cm)	0.761**			
1000 grain wt. (g)	-0.78**	-0.569*		
Grain yield Kg/ha	-0.659**	-0.623**	0.572**	
Oil content %	-0.291^{ns}	-0.217^{ns}	0.512*	0.474*

* = Significant, ** = Highly significant, ns= Non significant

Correlation studies: The correlation coefficients generally highlight the pattern of association among yield components and growth attributes, depicting how yield, as a complex character is expressed. Maturity is positively correlated with the height (0.761**), indicating that early maturing mutants are also short stature, but negatively (-0.659**) correlated with grain yield exhibiting that early maturity was associated with high yield. Plant height showed negative correlation with grain yield kg ha^{-1} (-0.623**) which revealed that dwarf strains would be high yielding as was observed in case of our study (Table 4). Similar findings have also been reported by Thakral (1982); Pathak *et al.*, 1986; Singh *et al.*, 1979 and Das *et al.*, 1984. Thousand grain weight illustrated highly positive correlation with grain yield per unit area (0.572**), indicating bold seededness give high yield as Yadava *et al*., (1973) demonstrated that seed per pod and 1000-seed weight directly influenced the seed yield in mustard.

Overall performance of the genotypes for yield and yield components indicate that the mutants S 97-75/36, S 97-1.0E/20 and S 97-1.0E/21 because of their high yield potential, hold great promise to be a mutant variety. Moreover, this suggests that gamma rays irradiation with the dose range of 750 to 1000 Gy and EMS with the dose range of 0.75% to 1.00% can be fruitfully applied to develop new varieties with high yield and other improved agronomic traits in oleiferous Brassica.

References

Anonymous. 2002. *Agricultural Statistics of Pakistan*, 2000-2001. MINFAL, Govt. Pakistan.

Chauhan, Y.S. and K. Kumar. 1986. Gamma rays induced chocolate – seeded mutant in *Brassica cam*pestris L. cv. Yellow Sarson. *Current Sci. India*, 55: 410.

Das, M.K., L. Rahman and M.A. Quddus. 1984. Correlation and path analysis in parents and F_3 of *B. juncea* x *B. campestris*. *Bangladesh J. Agric.*, 9: 1-2.

Das, M.L. and A. Rahman. 1988. Induced mutagenesis for the development of high yielding varieties in mustard. *J. Nucl. Agric. and Biol*., 17: 1-4.

Das, M.L. and A. Rahman. 1994. Evaluation of mutants of rapeseed for earliness, seed yield and response to changing environments in M_5 generation. *Bang. J. Nucl. Agric.*, 10: 75-80.

Gomez, K.A. and A.A. Gomez. 1984. *Statistical Procedures for Agricultural Research.* John Wiley & Sons, USA.

Javed, M.A., A. Khatri, I.A. Khan, M. Ahmad, M.A. Siddiqui and A.G. Arain. 2000. Utilization of gamma irradiation for the genetic improvement of oriental mustard *Brassica juncea* (L.) Coss. *Pak. J. Bot*., 32: 77-83.

Larik, A.S. and M. Hussain. 1990. Heterosis in Indian mustard *Brassica juncea* (L.) Coss. *Pak. J. Bot.*, 22 (2): 168-171.

Mahla, S.V.S., B.R. Mor and J.S. Yadava. 1990. Effect of mutagens on yield and its component characters in mustard. *Haryana Agric. Univ. J. Res.*, 20: 259-264.

Mahla, S.V.S., B.R. Mor and J.S. Yadava. 1991. Mutagen induced polygeneic variability in some mustard (*Brassica juncea* L.) varieties and their hybrids. *J. Oilseed Res.*, 8: 173-177.

Maluszynski, M., K. Nichterlein, L. Van Zanten and B.S. Ahloowalia. 2000. Officially released mutant varieties. The FAO/IAEA. Database. *Mut. Breed. Rev.*, No. 12, pp.1-84, IAEA, Vienna, Austria.

Naz, R.M.A. and R.Z. Islam. 1979. Effect of irradiation of *Brassica trilocularis* (yellow sarson). *Pak. J. Agric. Res.*, 17: 87-93.

Pathak, S.C., F.P. Chaudhry and S.K. Dixit. 1986. Selection criteria for seed yield in mustard (*B. Juncea* L.). *Madaras Agric. J.*, 71: 758-762.

Olejniczak, J. and E. Adamska. 1999. Achievement of mutation breeding of cereal and oilseed crops in Poland. *Proc. 3rd Int. Symp. New Genetical Approaches to Crop Improvement*. (eds. Arain *et al.*,) Nuclear Institute of Agriculture, Tando Jam, Allied Printing Corporation, Hyderabad, Pakistan, pp. 55-63.

Rehman, A., M.L. Das, M.A.R. Howlidar and M.A. Mansur. 1987. Promising mutants in *Brassica campestris*. *Mut. Breed. Newsletter*, 29: 14-15.

Rehman, A. 1996. New mutnat cultivar, *Mutation Breeding Newsletter*, 42: 27.

Rizvi, S.J.A. 2001. Economics and Bussiness Review, The *DAWN* (Karachi) October, 15-21, PIII.

Robbelen, G. 1990. Mutation breeding for quality improvement – a case study for oilseed crops. *Mut. Breed. Rev.*, 6: 1-44.

Singh, S.P., A.N. Srivastava and R.R. Katiyar. 1979. Path analysis in Indian colza. *Indian J. Genet. Pl. Breed.*, 39: 150-153.

Shah, S.A., I. Ali and K. Rahman. 1990. Induction and selection of superior genetic variables of oilseed rape, *Brassica napus* L. *The Nucleus*, 7: 37-40.

Shah, S.A., I. Ali and K. Rahman. 1998. Use of gamma rays induced genetic variability for the improvement of oilseed rape (*Brassica napus* L.). *Proc. 2nd Int. Symp. New Genetical Approaches to Crop Improvement*, (Eds.): Naqvi *et al.*, Nuclear Institute of Agriculture, Tandojam, Pakistan Printing Press Corporation, Karachi, Pakistan, pp. 229-237.

Shah, S.A., I. Ali, M.M. Iqbal, S.U. Khattak and K. Rahman. 1999. Evolution of high yielding and early flowering variety of rapeseed (*Brassica napus* L.) through *In vivo* mutagenesis. *Proc. IIIrd Int. Symp. New Genetical Approaches to Crop Improvement*, (Eds.): Arain *et al.*, Nuclear Institute of Agriculture, Tando Jam, Allied Printing Corporation, Hyderabad, Pakistan, pp. 47-53.

Thakral, N.K. 1982. To study the association of some morpho-physiological attributes with yield in toria (*B. campestris* Var. Toria). *Thesis Abstr.*, 8(1): 66-67.

Yadava, T.P., H. Singh, V.P. Gupta and R.K. Rana. 1973. Heterosis and combining ability in raya for yield and its components. *Indian J. Genet. Pl. Breed.*, 34: 684-695.

(Received for publication 17 October 2002)