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Development of High Yielding Mutants of *Brassica campestris* L. cv. Toria Selection Through Gamma Rays Irradiation

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Abstract: Homogeneous seeds of *Brassica campestris* L. cv. Toria selection were treated with different doses of gamma rays (750, 1000 and 1250 Gy) to induce genetic variability for the selection of new genotypes with improved agronomic traits. After passing through different stages of selection, two promising mutants were selected for further studies. Two selected mutants along with 5 other entries including parent variety were evaluated for yield and yield components in yield trials for two consecutive years. The mutant TS96-752 was significantly ($P \leq 0.05$) superior to all other entries in grain yield but at par with FSD 86028-3.

Key word: *Brassica campestris*, Toria selection, gamma rays, mutants

Introduction

Pakistan is overwhelmingly an agrarian economy, but it is unable to produce edible oils sufficient for domestic requirements due to which substantial amount of foreign exchange is spent on its import. There is about 3-4% increase in the import bill of edible oil every year. In order to save an average out flow of foreign exchange of about $ 700 million on account of import of edible oils, annually there is a strong and an urgent need to accelerate efforts to increase the local production of oilseeds (Rizvi, 2001). Oleiferous Brassica (rapeseed and mustard) is an important oilseed crop of Pakistan but its production per unit area is very low i.e., 908 kg ha^{-1} (Anonymous, 2000). There are many factors responsible for its low yield per unit area 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.

Introduction of genetic variability is prerequisite for the evolution of high yielding varieties. Induced mutation has been extensively used for creating new genetic variation in crop plants. More than 2200 mutant varieties of different crops with improved agronomic traits have been developed and released to the farmers for general cultivation in the world (Maluszynski *et al*., 2000). Mutagenesis has also been very successfully employed in rapeseed and mustard by the plant breeders to alter the genetic architecture of plant and isolate the mutants with desired economic 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 (Javed *et al*., 2000; Mahla *et al.,* 1990, 1991; Rehman *et al.,* 1987; Rehman, 1996; Robbelen, 1990; Shah *et al.,* 1990, 1998, 1999).

The present study was therefore, carried out to evaluate the performance of newly developed mutants of *Brassica campestris* L. cv. Toria selection for yield and yield components under agroclimatic conditions of Tandojam, Sindh.

Materials and Methods

The research work was conducted at Nuclear Institute of Agriculture, Tandojam for two consecutive years i.e., 1998-99 and 1999-2000. Homogeneous seeds of *Brassica campestris* L. cv. Toria selection were irradiated with 750, 1000 and 1250 Gy of gamma rays from cesium-137 (Cs^{137}) at the dose rate of 30.80 Gy per minute to induce new genetic variability for the selection of improved genotypes. Selection for the desired agronomic traits were carried out in different stages. Of hundreds of mutated population, two mutants TS95-1005 and TS96-752 were selected on the basis of promising performance for grain yield and other characters.

Two promising mutants (TS95-1005 and TS96-752) along with parent variety (Toria selection) and four high yielding genotypes (SMP67, FSD 850347, FSD 86028-3 and Poorbi Raya) were evaluated in yield trial in RCBD design with three replicates. Each plot consisted of four-meter long five rows 45 cm apart. Ten plants were selected from each plot to record the data on yield and yield components while three central rows were harvested to estimate yield per unit area. The data were analyzed statistically according to Gomez and Gomez (1984) and the mean values were compared by DMR test at 5% level of significance.

Results and Discussion

Significant ($P \leq 0.05$) differences were observed amongst all the entries for the traits under evaluation. The variety Toria selection and its mutants were found at par with each other in stature but significantly shorter than other genotypes. The minimum plant height was recorded in TS95-1005 (143.30) during 1998-99 (Table 1). Similar trend was observed in subsequent years (Table 2) and pooled data over the years (Table 3).

Plant height is an important yield contributing character in oleiferous Brassica. The reduction in plant height causes an increase in grain yield because of good response to higher doses of fertilizer and tolerance to lodging under unfavourable weather conditions. Moreover, the dwarfness in plant height is associated with earliness in maturity (Olejniczak and Adamska, 1999), which is a highly desirable character in crop plants. Chauhan and Kumar (1986), Das and Rahman (1988) 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 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).

All the genotypes were significantly superior to Toria selection in primary branches. The entries FSD 850347 (386) and TS96-752 (383) were at par with each other but significantly superior to other ones in pods per plant. Toria selection and its mutants were at par with each other but better than other genotypes in pod length. Both the mutants TS95-1005 and TS96-752 had higher number of grains per pod (16.97 and 16.97) and 1000 grain weight (3.84 and 3.82) respectively than the remaining entries. Three genotypes SMP 67 (16.16) FSD 86028-3 (16.19) and TS 96-752 (17.12) were equal to each other but superior to other ones in grain yield per plant during 1998-99 (Table 1). A little variation was observed in yield and yield components during 1999-2000 (Table 2). This phenomenon may be attributed to the prevailing environmental factors. However, the overall results indicated that the genotypes TS 96-752 (15.80), FSD 86028 (15.31) and SMP 67 (15.25) gave higher yield per plant (Table 3).

Breeding for high yield is based on the generation of new genotypes with improved yield components or the characters, which are responsible for substantial increase in yield. The genotypes FSD 86028-3 (2278) and TS 96-752 (2055) were at par with each other but significantly ($P \leq 0.05$) superior to other entries in grain yield (kg ha^{-1}) during 1998-99 (Table 1). The mutant TS96-752 produced significantly high yield (1843) as compared with all other genotypes during 1999-2000 (Table 2). The same performance was observed in pooled data over experimental years (Table 3).

The most important factors responsible for an increase in the productivity in oilseed Brassica are the number of primary branches, pods per plant, number of grains per pod and an increase in seed index (weight/grain). Pods on the main stem is the most productive factor and this could be possibly increased by decreasing the number of branches (Beg, 1984). The mutant TS 96-752 and genotypes (FSD 850347, FSD 86028-3 and SMP 67) have not only produced the higher number of primary branches, but also higher pods per plant (Table 3). Genotypes with more branches and pods per plant have also been reported in oilseed Brassica (Chauhan and Kumar, 1986; Naz and Islam, 1979; Shah *et al.*, 1990) as a consequence of mutagenesis. Yadava *et al.* (1973) demonstrated that seed per pod and 1000-seed weight directly influenced the seed yield in mustard. The genotype FSD 850347 showed highest 1000-grain weight (4.17) followed by mutants TS 95-1005 (3.88) and TS 96-752 (3.82). Both the mutants exhibited higher 1000-grain weight than the parent Toria selection, which probably indicates an increase in the size of grain as a result of induced mutation. This is in conformity with the findings of Chauhan and Kumar (1986) and Shah *et al.* (1990), who have also reported the bold-seeded mutants in oilseed Brassica.

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 SMP 67 (40%) followed by FSD 86028-3 (38.17%) and FSD 850347 (37.33%) during 1998-99 (Table 1). The genotype SMP67 (39.83 and 39.91) maintained its superiority during 1999-2000 (Table 2) and pooled over the years (Table 3) respectively. However, the mutant strain TS96-752 was significantly superior to its parent in oil yield per unit area (711.2 kg ha^{-1}) but at par with other entries during 1998-99 (Table 1). Its performance for oil yield (595.3 kg ha^{-1}) was equivalent to all other entries during 1999-2000 (Table 2). The overall average (670.5 kg ha^{-1}) indicated its superiority over parent (Table 3).

The correlation coefficients generally highlight the pattern of association among yield components and growth attributes, depicting how yield, as a complex character is expressed. Plant height showed positive correlation with primary branches (0.512), pods/plant (0.509), grain yield per unit area (0.581) and oil content (0.740) while negatively correlated with pod length (-0.637) and grains/pod (-0.545) (Table 4). The findings indicate that

Table 1: Performance of promising genotypes in yield trial during 1998-1999

Varieties/ mutant	Plant height (cm)	Primary branchs	Pods/ plant	Pod length (cm)	Grains pod^{-1}	1000 grain wt. (g)	Grain yield/ plant (g)	Grain yield (kg ha^{-1})	Oil content (%)	Oil yeild (kg ha^{-1})
SMP67	178.80a	5.80a	349.1ab	4.24b	12.8b-d	2.44d	16.16a	1917b	40.00a	766.7ab
FSD 850347	178.10a	6.00a	386.0a	4.19b	13.18bc	4.13a	13.78b	1944b	37.3a-c	724.1ab
FSD 86028-3	172.50a	6.50a	299.9bc	4.02b	11.86d	3.24b	16.19a	2278a	38.17ab	864.4a
POORBI RAYA	177.40a	6.00a	277.9cd	4.02b	12.09cd	2.84c	12.81bc	1985b	36.17bc	698.2ab
TS 95-1005	143.30b	5.93a	237.5de	4.58ab	16.97a	3.84a	13.53bc	1611c	36.17bc	581.8bc
TS 96-752	151.10b	5.90a	383.0a	4.93a	16.97a	3.82a	17.12a	2055ab	34.67cd	711.2ab
Toria selection (P)	144.20b	4.47b	204.1e	4.82a	13.89b	2.97bc	11.20c	1417c	32.83d	463.7c

Table 2: Performance of promising genotypes in yield trial during 1999-2000

Varieties/ mutant	Plant height (cm)	Primary branchs	Pods $plant^{-1}$	Pod length (cm)	Grains pod^{-1}	1000 grain wt. (g)	Grain yield/ plant (g)	Grain yield (kg ha^{-1})	Oil content (%)	Oil yeild (kg ha^{-1})
SMP67	174.3ab	4.93a	247.10a	4.71a	13.67a	3.87bc	14.33ab	1671bc	39.83a	667.9a
FSD 850347	173.0ab	4.20b	246.10a	4.77a	14.86a	4.21a	13.50ab	1558cd	38.42ab	599.1ab
FSD 86028-3	181.7a	4.13b	262.50a	4.78a	15.22a	3.78c	15.10a	1703b	36.3a-c	606.9ab
POORBI RAYA	171.8ab	4.33ab	219.10b	4.71a	15.35a	3.81bc	14.07ab	1673bc	36.7abc	614.7ab
TS 95-1005	153.7c	4.30ab	222.10b	4.96a	14.27a	3.93b	12.82bc	1488d	35.33bc	525.3b
TS 96-752 162.8bc	4.60ab	261.6a	4.98a	14.09a	3.82bc		14.48ab	1843a	34.17c	595.3ab
Toria selection (P)	151.9c	4.27ab	207.9b	4.71a	14.15a	3.79c	11.37c	1652bc	35.83bc	594.7ab

Table 3: Performance of promising genotypes in yield trials (pooled over years)

Varieties/ mutant	Plant height (cm)	Primary branchs	Pods $plant^{-1}$	Pod length (cm)	Grains pod^{-1}	1000 grain wt. (g)	Grain yield/ plant (g)	Grain yield (kg ha^{-1})	Oil content (%)	Oil yeild (kg ha^{-1})
SMP67	176.57a	5.36a	298.1ab	4.47bc	13.26b	3.16d	15.25a	1794c	39.91a	716.1ab
FSD 850347	175.53a	5.10a	316.13a	4.48bc	14.02b	4.17a	13.64b	1751c	37.87b	663.4b
FSD 86028-3	173.80a	5.33a	281.2ab	4.40bc	13.54b	3.51c	15.31a	1991a	37.76bc	741.4a
POORBI RAYA	174.60a	5.17a	248.50c	4.36c	13.72b	3.33cd	13.35b	1829bc	36.59bc	669.5b
TS 95-1005	148.50c	5.11a	229.7cd	4.77ab	15.62a	3.88b	13.18b	1549d	35.89cd	553.8c
TS 96-752 156.93b		5.25a	322.28a	4.95a	15.53a	3.82b	15.80a	1949ab	34.42d	670.5b
Toria selection (P)	148.10c	4.37b	206.00d	4.77ab	14.02b	3.38c	11.28c	1534d	34.34d	527.2c

Table 4: Correlation coefficient ‘r’ among nine characters in oleiferous Brassica

	Primary branch plant	Pods $length^{-1}$	Pod (cm)	Grains pod^{-1}	1000 grain wt. (g)	Grain yield/ plant (g)	Grain yield (kg ha^{-1})	Oil content (%)
Plant height (cm)	0.512*	0.509*	-0.637*	-0.545*	-0.171NS	0.433*	0.581*	0.740**
Primary branchs		0.589*	-0.130NS	-0.046NS	-0.010NS	0.620*	0.510*	0.459*
Pods $plant^{-1}$			-0.152NS	-0.050NS	0.334NS	0.707**	0.635*	0.372NS
Pod length (cm)				0.586*	0.175NS	0.048NS	-0.188NS	-0.515*
Grains pod^{-1}					0.550*	0.037NS	0.147NS	0.571*
1000 grain wt. (g)						0.018NS	0.037NS	-0.193NS
Grain yield/ plant (g)							0.740**	0.380NS
Grain yield (kg ha^{-1})								0.199NS

Means followed by the same letters are not significantly different from each other at 0.05%, *= Significant, **= Highly significant, NS= Non significant

pod length and grains/pod may have positive correlation with short stature varieties. Similarly, primary branches showed positive correlation with all characters, except pod length, grains/pod and 1000 grain weight. Similar findings have also been reported by Thakral (1982); Pathak *et al.* (1986); Singh *et al.* (1979) and Das *et al.* (1984). Pod per plant showed highly positive correlation with grain yield per unit area (0.635) whereas pod length showed significantly ($P \leq 0.05$) negative correlation with oil content (-0.515). Grains/pod exhibited positive correlation with 1000 grains weight (0.550) and oil content (0.571).

It was concluded that the overall performance of the genotypes for yield and yield components indicates that the mutant TS 96-752, because of its high yield potential, holds great promise to be a mutant variety. Moreover, this suggests that gamma rays irradiation with the dose range of 750 to 1000 Gy can be fruitfully applied to develop new varieties with high yield and other improved agronomic traits in oleiferous Brassica.

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