Tropical Agricultural Research and Extension 3 (1): 19 -24, 2000

Development and release of gamma ray induced sesame mutant ANK-S2 in Sri Lanka

R. Pathirana[1], L.A. Weerasena[2] and Priyanthi Bandara[2]

[1]Department of Agricultural Biology, Faculty of Agriculture, University of Ruhuna, Kamburupitiya, Sri Lanka.
[2]Agricultural Research Station, Department of Agriculture, Augunakolapelessa, Sri Lanka.

Accepted: 12 December 1999

ABSTRACT

Epiphytotic conditions and non-availability of resistant germplasm prompted the use of mutation induction technique to develop a variety resistant to phytophthora blight caused by *Phytophthora nicotianae* var. *parasitica* in sesame (*Sesamum indicum* L.). Dry seeds of three varieties were irradiated with six doses of ^{60}Co gamma rays in the range 100-700 Gy. The mutant line 182/3 of variety MI 3 selected from 200 Gy dose treatment in the M_2 showed tolerance to the disease at Angunakolapelessa in the disease nursery. The mutant line was tested in the advanced yield trial, National Co-ordinated Varietal Trials and in the National Coordinated Varietal Adaptability Trials. It was superior to MI 3 in yield and plant survival during the seasons favouring development of the disease and was similar to MI 3 and other recommended varieties during the other seasons. The variety has cream coloured seeds, branched stem, and recorded 1890 kg ha^{-1} at Girandurukotte, 1593 kg ha^{-1} at Maha Illuppallama and 1151 kg ha^{-1} at Angunakolapelessa under rainfed conditions. The mutant was released as ANK S2 in 1993 and may be used to increase the declining sesame area due to low yield of existing varieties and their susceptibility to disease. It should also serve as valuable parent material in cross-breeding programmes.

Key words: Disease resistance, induced mutations, oil crops, *Phytophthora, Sesamum indicum*

INTRODUCTION

Ease of cultivation, drought resistance and the high quality of oil have made sesame (*Sesamum indicum* L.) an important oil seed crop in many countries with arid climates. Relatively large area of production recorded in Sri Lanka in the 1970s and 1980s, which ranged from 30,000 ha 40,000 ha has shown a declining trend in the 1990's, with only 9000 ha in 1992. Diseases and poor yields resulting in low income to the farmers have been attributed to this decline in production (Pathirana 1992; Anon. 1996). The main disease affecting sesame in the Dry Zone of Southern Sri Lanka has been identified as due to *Phytophthora nicotianae* var. *parasitica* (Pathirana 1992). The screening of more than 250 local and exotic sesame germplasm accessions failed to reveal any sources of resistance (Pathirana 1984a, 1984b). Due to the non-availability of germplasm resistant to the disease, a mutation breeding programme was initiated to develop cultivars tolerant of this disease. Mutation induction and selection in early generations under epiphytotic conditions have been reported earlier (Pathirana 1992). This paper describes the performance of a mutant line 182/3 isolated from the recommended variety MI 3, in the variety testing programme of the Department of Agriculture.

MATERIALS AND METHODS

The promising mutant lines selected from the preliminary trials (Pathirana 1992) along with other promising breeding material from the cross breeding programme were tested in the advanced yield trials at the Regional Agricultural Research Station, Angunakolapelessa located in the Dry Zone of Southern Sri Lanka. This is an area with high incidence of the disease. In the advanced yield trials, 12 -14 breeding lines were included in a randomized complete block design with 3 replications. Each plot consisted of five rows of 5 m length spaced at 30 cm between plants with-in a row.

After testing at least for two seasons, the promising material were advanced to the National Co-ordinated Varietal Trials conducted at different dry zone research stations of the Department of

Agriculture. These trials were planted in four replications in Randomized Complete Block Design with a plot size of 5x3 m, maintaining the same plant spacing as described for the advanced yield trials. The plots received the recommended fertilizer levels for sesame *viz* 30, 120 and 60 kg ha^{-1} N, P and K in the form of urea, triple superphosphate and muriate of potash respectively, at the time of planting. Another 30 kg ha^{-1} of urea was applied four weeks after planting, during the early flowering stage. Weed control was conducted manually.

In all the field experiments, the seed yields per plot were estimated by harvesting the net plot, leaving the border rows and 30 cm from both ends of the plot. *Phytophthora* incidence was recorded at the late flowering stage, as percentage of plants affected (Choi *et al.* 1987). The data were analysed statistically using analysis of variance, and the least significance difference test was used to compare mean differences. The percentage values were log transformed before subjecting to statistical analysis.

After testing for a minimum of two seasons in the National Co-ordinated Varietal Trials, the most promising line or two were advanced to the Co-ordinated Varietal Adaptability Trials conducted in the farmers' fields under their management conditions. In these trials, only two or three breeding lines were tested using one recommended variety as the control. The plot size in these trials varied from 50 m^2 to 150 m^2. The Co-ordinated Varietal Adaptability Trials were conducted under the supervision of District Agriculture Extension personnel of the Department of Agriculture, Sri Lanka.

RESULTS

Advanced Yield Trials

The mutant line 182/3 was tested along with other promising breeding lines and with three recommended varieties MI 1, MI 2 and MI 3 in the major yield trial at the Agricultural Research Station, Angunakolapalessa in 1984 during the southwest monsoon season in 1984/85, northeast monsoon season. Both seasons were conducive for the development and spread of *Phytophthora* disease and the mutant line recorded significantly higher yield than the best of the recommended varieties during those season (Tables 1, 2).
MI 3 variety, the parent cultivar of 182/3 line was the most affected by the disease and the mutant line was the least affected. In the southwest monsoon season (1984), the mutant line recorded 52% higher yield than the highest yielding recommended variety (Table 1) and in the northeast monsoon season (1984/85), it exceeded the yield of the best among the recommended varieties by 21% (Table 2). Again, the parent cultivar of the mutant line was the worst affected by the disease and the mutant line was the least affected.

Table 1. Yield performance and incidence of phytophthora blight in the advanced yield trial at Angunakolapelessa (Southwest monsoon season, 1984)

Variety	Seed yield, kg ha^{-1}	Seed yield[a], %	% Incidence of Phytopthora
ANKS2	675	151.7	10.8
MI3	421	94.6	58.8
MI-1	385	86.5	52.1
MI-2	445	100.0	49.6
LSD 5%	142		18.8
LSD1%	268		38.3

a- highest yielding recommended variety taken as 100%

Table 2. Yield performance and incidence of phytophthora blight in the advanced yield trial at Angunakolapelessa (northeast monsoon season, 1984/85)

Variety	Seed yield, kg ha^{-1}	Seed yield[a], %	% Incidence of Phytopthora
ANK S2	569	120.8	12.1
MI3	356	75.6	65.2
MI-1	471	100.0	66.7
MI 2	418	88.8	57.8
LSD 5%	151		20.8
LSD 1%	288		42.6

a highest yielding recommended variety taken as 100%

After two seasons of testing in the advanced yield trials, the mutant was advanced to the National Co-ordinated Varietal Testing Programme.

National Co-ordinated Varietal Trials

The mutant line was tested in the National Co-ordinated Varietal Trials of sesame for five seasons starting with the southwest monsoon season of 1987. The parent variety MI 3 was used as the control in these experiments. During the southwest monsoon season of 1987, the mutant significantly exceeded the yield of MI 3 variety at Aralaganwila in the Polonnaruwa District. However its yield was significantly lower than the parent at Wariyapola in the Kurunegala District. The yield differences between the mutant and the parent variety at Maha Illuppallama and Angunakolapelessa were not high and were not significant statistically (Table 3). The cultivars were not affected by the disease during this Season. In 1987/88, during the northeast monsoon season, the disease incidence was relatively high and the mutant recorded a significant yield increase at Angunakolapelessa (Table 4).

Table 3. Comparison of yield (kg ha⁻¹) in the National Coordinated Varietal Trials (southwest monsoon season, 1987/88)

Variety/line	Angunakola-pelessa	Maha Illu-ppallama	Wariyapola	Mean	Aralaganwila
182/3	1151	986.5	682.1	868.1	652.7
MI-3	1013	1112.1	1327 7	967.3	416.5
Mean[a]	959.5	855.4	924.8		447.8
LSD 5%	NS[a]	NS	551.7		166.9
LSD 1%			753.1		225.5

a - mean of 12 entries tested
B - NS - non significant

Table 4. Comparison of yield (kg ha -1) in the National Coordinated Varietal Trials (southwest monsoon season, 1978)

Variety/line	Angunakola-pelessa	Aralaganwila	Wariyapola	Mean
182/3	756	174	434	400.0
MI3	279	215	706	400.0
Mean[a]	331	240	697	
LSD 5%	NS[b]	NS	434	

a - Mean of 12 entries tested
b - NS - non significant

When averaged over the three locations where the NCVT was conducted, the mutant out-yielded its parent by 13.5%. Due to disturbances during the conduct of field experiments, only the yield data for Girandurukotte could be collected in 1989 southwest monsoon season, and the mutant recorded the highest yield of 1898 kg ha^{-1} (Table 5). The yields of all varieties were low in southwest monsoon season 1990 and the differences were not significant (Table 5). In the subsequent northeast monsoon season (1990/91), the variety MI 3 was tested with the mutant line at two locations. The disease was not observed during this season and the yield of the mutant was comparable to its parent at these two locations (Table 6).

National Co-ordinated Varietal Adaptability Trials

Due to the already recorded tolerance of the mutant line 182/3 to *Phytophthora* blight and its superior orequal performance during several seasons of testing in the National Coordinated Varietal Trials it was promoted to the National Coordinated Varietal Adaptability Trials prior to release. Thus it was tested along with MI 3 cultivar in three regions during 1990/91, northeast monsoon season. At all The regions and in all locations of different regions, the mutant recorded higher yield compared to the Parent cultivar (Table 7). The overall yield advantage of the mutant 182/3 against the popular MI 3 variety was 35.4%. National Coordinated Varietal Adaptability Trials were conducted at five locations during locations during 1991, southwest monsoon season.1991, southwest monsoon season. Again the mutant recorded higher yield than the parent cultivar at all locations, giving a mean yield increase of 15.1% (Table 8). The mutant line 182/3 was officially released by the Department of Agriculture, Sri Lanka in 1993 under the name ANK S2. The characteristics of the new variety are given in Table 9.

Table 6. The yield performance (kg ha⁻¹) of mutant line 182/3 and its parent at the National Coordinated Varietal Trials at two siter during northeast monsoon season.

Variety	Angunakola-pelessa	Weerawila
182/3	540	853
MI	484	865
F	NS[a]	NS

a - NS - non significant

DISCUSSION

Chemical control of sesame diseases is difficult and seldom economic. Improved agricultural practices

Table 5. Comparison of yield (kg ha⁻¹) in the National Coordinated Varietal Trials during the southwest monsoon seasons, 1989 and 1990

Variety	Giranduru-kotte - 1989	Giranduru - kotte 1990	Aralaganwila -1990	Maha Illuppllama -1990	Weerawila -1990
182/3	1898	246	220	1890	428
MI 3	1436	189	446	1888	336
LSD 5% -	NS[a]	NS	NS	99.4	NS
LSD 1% -	NS[a]			136.3	

a- NS - Non significanta

Table 7. Yield performance (kg ha-1) mutant 182/3(ANK -S2) in National Co-ordinated Varietal Adaptability Trials, north west monsoon season 1990/91

Variety	L1[a]	L2	L3	L4	Mean
			Angunakolapelessa region		
ANK - S2	518	584	321	608	507
MI -3	368	412	293	425	375
			Maha Illuppallama region		
ANK-S2	658	412	701	753	631
MI-3	508	315	451	541	454
			Wariyapola region		
ANK-S2	521	542	482		515
MI-3	394	381	401		392

a - LI - L4 indicate different locations within a region

Table 8. Yield performance of (kg ha-1) of mutant 182/3(ANK -S2) in National Coordinated Variety Adaptability Trials, at MI region south west monsoon season 1991.

Variety	L1[a]	L2	L3	L4	Mean
ANK - S2	628	614	501	562	576
MI - 3	495	508	493	512	502

a - LI -L4 indicate different locations with in the region

would lose much of their value unless accompanied by research into methods of increasing disease resistance (Weiss 2000). Disease resistance is a major concern in sesame breeding (Ashri 1982; Weiss 2000), but vary few efforts have been made to develop disease resistant sesame cultivars (IAEA 1994). This may be due to the lack of easy methods for disease screening and also the non-availability of resistant material in germplasm collections for cross breeding (Kolte 1985; Verma 1985). However, in programmes where a large number of entries have been screened, genetic variability for resistance hasbeen observed. Thus, for example, Bakheit *et al.* (1988) reported high variability for *Rhizoctonia solani, Fusarium oxysporum* and *Macrophomina phaseolina* in a sesame collection in Egypt. In China too, resistance to *M. phaseolina* has been found among local cultivars as well as among exotic ones(Li *et al.* 1989). Nevertheless, sesame cultivars considered resistant in a particular area or country, frequently proved highly susceptible elsewhere (Weiss 2000). This may be the reason why we could not find material resistant to *Phytophthora* disease in the germplasm screening experiments (Pathirana 1984a, 1984b). A well-designed programme for developing disease resistant sesame cultivars has been continuing in Korea for several years. Selection for resistance to *Phytophthora* blight was possible when 20-day-old seedlings were infected by inoculating the soil with 200 sporangia/ml and the

Table 9. Characteristics of new mutan variety ANK S2

Name of the variety	- ANK S2
Source	- RARC/Angunakolapelessa
Pedigree	- A mutant variety derived from Var. MI-3 irradiated with [60]CO Gamma rays at 200 GY
Photoperiod sensitivity	- Insensitive
Leaf colour	- Pale green
Plant height	- 80 cm
Stem height of the yielding part	- 49 cm
Branching habit	- Branched from bottom
Number of branches per plant	- 5
Flower colour	- Light purple
Number of days from planting to Harvesting	- 78- 80 days (2 1/2 months)
Plant height to 1[st] capsule	- 31 cm
Number of nodes to the 1[st]	- 6
Capsule	- 3.4 cm
Capsule length	- 3.4
Number of locules per capsule	- 4
Number of capsules per axil	- 1
Number of capsules per plant	- 46
Seed colour	- Cream
1000 seed weight	- 3.8 g
Reaction to diseases	-Tolarant to phytopthera blight disease
Potential yield	- 1890 kg ha[1] (Girandurukotte) 1593 kg -1 (Maha Illuppallama) 1151 kg ha-1 (Angunakolapele ssa)

pots were half-immersed in water. Screening of 70-day-old plants following spray or soil inoculation was also a successful method of identifying resistant plants (Choi *et al.* 1987). Use of this screening technique on induced mutants has resulted in both directly released mutants and cross-bred varieties. For example, X-ray irradiation of seeds with 200 Gy Early Russian variety has led to the development and release of the disease resistant mutant Ahnsankkae, which occupies a large proportion of sesame fields in South Korea (Kang and Van Zanten 1996). This variety and other mutants have later served as initial material for development of several disease resistant and high oil quality cultivars having improved yield, among which *Phytophthora* resistant Suwonkkae is a leading variety (Lee *et al.* 1992; Kang 1994, 1995).

In our experiment, a disease nursery with inoculum build up was used and the disease severity was sufficient to select tolerant plants (Pathirana 1992). A newly emerging method of disease resistant breeding is regeneration of somaclones in media supplemented with fungal toxins. It has not been possible to apply this method to sesame breeding as plant regeneration *in vitro* is difficult. However, use of epicotyl segments of sesame in media treated with culture filtrates of the causal agents of charcoal root-rot (*Macrophomina phaseolina*) and wilt disease (*Fusarium oxysporum* f. sp. *sesami*) has resulted in some resistant plants (Abd-El-Moneem *et al.* 1997).

The Variety ANK S2 described in this paper, released by the Department of Agriculture, Sri Lanka is one of the few sesame mutants directly released for cultivation. It was developed from the recommended variety MI 3 irradiated at 200 Gy with ^{60}CO gamma rays. It is a variety with cream coloured seeds and takes about 78-80 days from planting to maturity. It is tolerant to *Phytophthora* blight and is superior to the recommended white seeded variety MI 3 and black seeded varieties MI 1 and MI 2 for yielding ability and for disease tolerance. The highest yield potentials recorded are 1898 kg ha^{-1} at Girandurukotte, 1890 kg ha^{-1} at Maha Illuppallama and 1151 kg ha^{-1} at Angunakolapelessa under rainfed conditions. This variety is more suitable for the southern dry region of Sri Lanka where the occurrence of *Phytophthora* blight is predominant. Nevertheless, high yield potential exhibited in other areas of the Dry Zone should make it a valuable cultivar for country-wide cultivation. As many other soil borne sesame diseases such as *Rhizoctonia solani, Fusarium oxysporum, Sclerotium rolfsii* and *Macrophomina phaseolina* are prevalent in the dry zone of Southern Sri Lanka, the durable resistance of this variety indicates multiple disease resistance and requires further investigations. The disease tolerant qualities of the mutant variety ANK S2 should be exploited not only to expand the declining sesame production area in the country, but also in cross breeding to develop new cultivars with improved traits.

ACKNOWLEDGEMENTS

This research was partly funded by the International Atomic Energy Agency, Vienna (RC 5442 RB) and the International Development Research Center, Canada under the National Oil Crops Development Project of the Department Agriculture, Sri Lanka. Contribution by the Department of Agriculture research personnel from the regional research stations and extension personnel from different regions in conducting regional trials is acknowledged.

REFERENCES

Abd-El-Moneem KMH, El-Farash EM and Fahmy FG 1997 *In vitro* selection for high elding somaclones resistant to charcoal root-rotnd wilt disease complex in sesame. Assiut J. Aric. Sci. 28: 201-224.

Ashri A 1982 status of breeding and prospects for mutation breeding in peanuts, sesame and castor beans. Pp. 65- 80. In: Improvement of Oil-Seed and Industrial Crops by Induced Mutations. International Atomic Energy Agency, Vienna.

Anon. 1996 Statistical Abstracts of the Democratic Socialist Republic of Sri Lanka. Department of Census and Statistics, Ministry of Finance and Planning, Colombo, Sri Lanka.

Bakheit BR, El-Hifny MZ, Mahdy EE, Gurguis N R and El-Shimy A. 1988 Evaluation of sesame genotypes for relative tolerance to root rot disease. Assiut J. Agric. Sci. 19: 255-264.

Choi SH, Cho EK and Chae YA 1987 An aluation method for sesame (*Sesamum indicum* L.) resistance to *Phytophthora nicotianae* var. *parasitica*. Korean J. Crop Sci. 32: 173-180.

IAEA 1994 Conclusions and Recommendations. In: Induced Mutations for Sesame Improvement, International Atomic Energy Agency, Vienna, Austria. pp. 48-51.

IAEA 1998 Report of the final research co-ordination meeting of the FAO/IAEA Co-ordinated Research Programme on Induced Mutations in Sesame Breeding held in Bangkok, Thailand. International Atomic Energy Agency, Vienna. pp. 1-4.

Kang CW 1994 Breeding sesame for disease, shatter resistance and high yield through induced mutations. In: Induced Mutations for Sesame Improvement, International Atomic Energy Agency, Vienna. pp 34-44.

Kang CW 1995 Mutation breeding for disease resistance and high yield of sesame (*Sesamum indicum* L.) in Korea. Sesame Safflower Newsl. 10 : 21-36.

Kang CW and Van Zanten L 1996 Induced mutations in sesame for determinate growth, disease and lodging resistance and high yield potential in South Korea. Mutation Breeding Newsl. 42: 21-22

Kolte SJ 1985 Diseases of annual edible oil seed crops. Rapeseed, mustard and sesame diseases. CRC Press, Boca Raton, Florida.

Lee JI, Kang CW, Lee BH and Park RK 1992 A non branching good quality and high yielding new sesame variety "Suwonkkae". [Korean] Research Reports of the Rural Development Administration, Upland & Industrial Crops: 34: 1, 91-96.

Li LL, Wang SY, Fang XP, Huang ZH, Wang ST, Li ML and Cui MQ 1991 Identification of *Macrophomina phaseolina*-resistant g ermplasms of sesame in China. [Chinese]

Oil Crops of China. No. 1, 3-6, 23. 3

Pathirana R 1984a Groundnut and sesame improvement in Sri Lanka. In: A.Omran (Ed.) Oil Crops. International Development Research Center, Ottawa, Canada. pp. 55-57.

Pathirana R 1984b Oilseeds improvement in Sri Lanka. In: K.W.Riley (Ed.) Oil Crops, International Development Research Centre, Ottawa, pp. 125-135.

Pathirana R 1985 Sesame varietal improvement in Sri Lanka: Objectives, methodology and achievements. Oil Crops Newsletter (Ed. A.Omran), 2: 67-68.

Pathirana R 1992 Gamma ray induced field tolerance to Phytophthora blight in sesame. Plant Breeding 108(4): 314-319.

Verma MC 1985 Sesame pathological problems and research progress in India. In: A. Omran (Ed.) Oil Crops: Sesame and Safflower, IDRC-MR 105, Ottawa. pp 44-77.

Weiss EA 2000 Oilseed Crops. Second Edition. Blackwell Science Ltd., London.