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Improvement of Groundnut (*Arachis hypogaea* L.) Productivity under Saline Condition Through Mutation Induction

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Abstract: This study was conducted during 2005-2008 on the Experimental Farm of South Valley University, Qena under saline conditions, to select for higher yield alongwith salinity tolerance from among 77 groundnut (*Arachis hypogaea* L.) variants. They were isolated in M2 generation after seed treatment to four groundnut varieties, Giza 5 and Giza 6 (erect types) and NC 9 and Gregory (runner types) with different doses of gamma rays and various concentrations of sodium azide. In the M3 and M4, selection was practiced based on high yield and low variances compared to the parent varieties. In M4 generation, 9 mutants were obtained and evaluated in preliminary trials with their respective parents, i.e. Giza 5, Giza 6 and NC 9 during M5 and M6 generations. Three out of nine mutants, namely, M6-13, M6-18 and M6-30 produced higher pod and seed yield/plant and more no. of pods and seeds/plant than their parents. In addition, good performance was appeared for each of branches/plant, seed index and shelling % for these three mutants in both generations and their combined. In conclusion, these three selected mutants were found to be the best and must to be put into future advanced yield trials in different locations before registration.

Key words: Groundnut · Improvement · Mutation induction · Gamma rays · Sodium azide · Salinity

INTRODUCTION

Groundnut seeds are important source of vegetable oil. In Egypt, it is grown in 3, 589, 740 ha mainly for direct consumption than for oil extraction [1]. To increase food production in line with population growth and to compensate the shortage of old planted area, it has become necessary to go for cultivation of the desert. Nevertheless, most of newly reclaimed lands and groundwater used for irrigation are saline. Salinity is one of the important abiotic stresses, which affects all stages of groundnut growth and finally the yield [2]. Soil amelioration against salinity is a costly and time-consuming procedure. Hence, the alternative strategy is to develop salinity-tolerant genotypes.

Since traditional breeding program through crossing and selection is difficult in groundnut, induced mutations is an alternative technique that was used extensively in many areas for groundnut breeding [3-12]. Kale *et al.* [13] from India and Hamid *et al.* [14] from Bangladesh developed several new groundnut varieties with superior agronomical traits by using mutation research, which were released for commercial cultivation for benefit of farmers.

Development of salinity-tolerant groundnut genotypes with high yielding ability, may contribute to increase the acreage in the new reclaimed lands without competition with the other crops cultivated in the old lands in Egypt. The objective of current study was to select groundnut mutants for higher yield with salinity tolerance.

MATERIALS AND METHODS

Experimental Site Description: This study was conducted on the Experimental Farm of the Faculty of Agriculture at South Valley University, Qena, Egypt (26°11'N and 32°44'E) during the period 2005-2008 in summer (May to September). The soil is sandy clay loam throughout its profile (68.44% sand, 13.01% silt and 18.55% clay). The soil and irrigation water salinity (EC_e) were 13.15 and 6.5 dS m^{-1}, respectively.

Mutant Selection and Development: The materials used were 77 promising mutants isolated based on high yielding ability, from M2 generation after seed treatments of four groundnut varieties, Giza 5 and Giza 6 (erect types)

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and NC 9 and Gregory (runner types) with 200, 300 and 400 Gy gamma rays at dose rate of 2.59 r/sec. and $1.0*10^{-3}$, $2.0*10^{-3}$ and $3.0*10^{-3}$ molar of sodium azide for 2 hrs. During 2005, 77 mutants were sown, each mutant in one row. Selection was applied and 39 out of 77 mutants were advanced to M4 generation based on high means and low variance compared to the mean yield and variance of the parent varieties. Same selection procedure was also practiced in the M4 and 9 mutants were selected. The selected mutants with their parents, Giza 5, Giza 6 and NC9, were evaluated in preliminary yield trials during 2007 and 2008.

Experimental Design and Agronomic Practices: A randomized complete block design with three replicates was used in preliminary trials. The experimental plot consisted of 4 rows each 3 m long with a spacing of 60 X 10 cm and 60 X 30 cm for erect and runner mutants/varieties, respectively. All the recommended agronomic practices were used.

Parameter Assessments: In each plot, number of days to 50% flowering were recorded and at harvest, from 15 plants were randomly selected and data on plant height (cm), no. of i) branches, ii) pods, iii) seeds/plant, pod (g) and seed yield/plant (g) and 100-seed wt. (g) were collected. Shelling % was calculated and oil content was estimated by Soxhelt apparatus according to A.O.A.C. [15].

Statistical Analysis: Data were statistically analyzed using an analysis of variance random complete block design for each preliminary trial, separately. Combined analysis over both the trials was also done after calculated coefficient of variation (c.v.) for each generation. Statistical analysis was done according to Gomez and Gomez [16]. Mean comparisons were performed at 5% level of significance using Revised Least Significant Differences (Revised L.S.D.) test.

RESULTS

Significance of Mean Squares: Data presented in Table 1 indicate that, differences among mutants/ varieties for the studied traits were significant at $P<0.01$ in M5, M6 and their combined except for branches/ plant ($P<0.05$) and days to 50% flowering which was insignificant in M6 generation. Combined analysis showed that, the differences due to seasons were insignificant for all studied traits except for days to 50% flowering and seed oil content which were significant ($P<0.01$) and each of branches/plant and seed index ($P<0.05$).

Performance of Mutants: Performance of the evaluated mutants and their parents under the salinity condition are given in Table 2 and showed in Figure 1.

Table 1: Significance of mean squares due to different sources of variation for studied traits in M5 and M6 generations and their combined

	Generations									
	M5			M6			Combined			
S.O.V	Reps	Mut. /Var.	Error	Reps	Mut. /Var.	Error	Gen. (a)	Mut. /Var. (b)	a*b	Error
D.f.	2	11	22	2	11	22	1	11	11	44
	Mean squares									
Trait	Mut. /Var.		Error		Mut. /Var.	Error	Gen. (a)	Mut. /Var. (b)	a*b	Error
NDF	52.39**		2.84		10.78	6.41	9545.01**	27.73**	35.4**	4.63
Pht	39.68**		4.20		28.34**	3.69	26.16	62.84**	5.18	3.95
NBP	1.12**		0.26		1.06*	0.28	2.0*	1.93**	0.24	0.27
NPP	43.42**		1.50		40.81**	3.10	5.01	79.85**	4.38	2.3
PYP	65.32**		2.20		51.58**	2.86	0.57	113.51**	3.39	2.53
NSP	31.39**		2.52		31.48**	1.54	11.68	60.07**	2.8	2.03
SYP	14.30**		0.53		10.77**	0.46	0.68	24.27**	0.81	0.50
SI	214.5**		16.67		185.03**	37.87	90.10*	306.26**	93.27**	27.27
Sh	216.84**		26.79		245.28**	37.49	60.48	315.45**	146.67**	32.14
Oil	51.43**		1.34		46.53**	2.45	8.79**	65.71**	32.58**	1.53

Mut/Var: Mutants/Varieties; Gen: generations.

NDF: number of days to 50% flowering; PHt: plant height (cm); NBP: number of branches/plant; NPP: number of pods/plant; PYP: pod yield/plant (g); NSP: number of seeds/plant; SYP: seed yield/plant (g); SI: 100-seed wt (g); Sh: shelling percentage; Oil: seed oil content percentage.

* $P<0.05$ and ** $P<0.01$

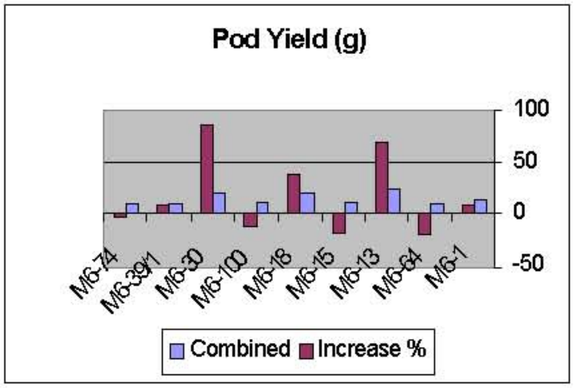
Table 2: Mean performance of mutants/varieties for yield and yield attributes in M5 and M6 generations and their combined

	Trait									
Mutants/Varieties	NDF	Pht	NBP	NPP	PYP	NSP	SYP	SI	Sh	Oil
M5 generation										
Giza 5 (control)	57.33	25.00	5.00	13.00	14.30	15.67	5.62	35.35	39.25	37.67
M6-1 (20 kr)	51.67	28.90	5.00	15.67	16.10	16.33	6.94	41.66	42.40	31.54
M6-64 (30 kr)	57.67	30.53	5.67	9.67	9.68	14.00	4.32	31.21	54.46	33.30
Giza 6 (control)	52.67	36.67	6.00	13.33	13.89	13.33	3.97	29.10	28.01	35.73
M6-13 (20 kr)	54.00	37.77	7.00	18.00	24.81	17.33	8.21	48.46	35.52	36.74
M6-15(1.0*10^{-3} M)	50.33	27.77	5.67	7.00	11.67	9.67	3.88	39.75	37.31	33.31
M6-18 (2.0*10^{-3} M)	49.00	30.00	6.00	19.67	18.74	17.33	10.18	57.87	53.98	27.28
M6-100 (1.0*10^{-3} M)	59.00	30.00	6.00	12.33	13.18	13.33	5.20	37.81	40.03	34.08
NC9 (control)	50.67	27.77	5.33	10.67	9.92	8.00	3.33	37.12	31.55	29.33
M6-30 (1.0*10^{-3} M)	52.33	28.33	5.33	16.67	19.22	18.67	8.36	48.20	43.53	37.18
M6-39/1 (3.0*10^{-3} M)	44.33	31.67	6.00	10.00	10.66	11.67	5.25	45.26	52.68	40.79
M6-74 (2.0*10^{-3} M)	49.33	31.10	6.67	10.33	9.85	12.67	3.91	31.77	41.09	40.46
Revised L.S.D at 5%	2.64	3.36	0.89	1.85	2.42	2.49	1.10	6.40	8.49	1.74
M6 generation										
Giza 5 (control)	75.33	27.50	5.00	14.67	13.70	16.00	5.56	37.50	41.02	33.98
M6-1 (20 kr)	71.33	26.67	5.67	13.00	14.10	15.67	6.55	40.90	45.14	30.34
M6-64 (30 kr)	72.67	32.23	6.33	11.33	12.90	11.33	3.50	32.32	31.28	28.72
Giza 6 (control)	76.00	36.67	6.33	13.67	14.44	13.33	3.77	29.38	25.91	36.50
M6-13 (20 kr)	75.67	35.57	7.00	20.33	22.98	15.67	7.28	46.71	32.07	30.96
M6-15(1.0*10^{-3} M)	75.67	30.00	6.33	10.67	11.79	10.00	4.01	40.64	38.16	35.02
M6-18 (2.0*10^{-3} M)	74.67	32.77	7.00	19.00	20.59	18.33	8.42	44.06	39.26	30.38
M6-100 (1.0*10^{-3} M)	78.00	32.20	6.00	13.33	11.83	13.00	6.14	46.56	56.69	31.55
NC9 (control)	76.33	30.00	5.33	10.67	10.62	8.00	3.23	38.95	29.35	38.56
M6-30 (1.0*10^{-3} M)	74.67	30.00	6.00	17.33	19.22	16.33	8.79	58.37	42.82	40.75
M6-39/1 (3.0*10^{-3} M)	77.33	35.00	6.33	8.67	11.48	11.33	5.07	44.28	48.92	39.26
M6-74 (2.0*10^{-3} M)	77.00	31.37	6.33	10.00	10.51	9.33	4.51	50.71	47.18	34.01
Revised L.S.D at 5%	5.66	3.15	0.92	2.76	2.65	1.95	1.09	10.75	10.05	2.45
Combined										
Giza 5 (control)	66.33	26.25	5.00	13.83	14.00	15.83	5.59	36.43	40.14	35.82
M6-1 (20 kr)	61.50	27.78	5.33	14.33	15.10	16.00	6.74	41.28	43.77	30.94
M6-64 (30 kr)	65.17	31.38	6.00	10.50	11.29	12.67	3.91	31.77	42.87	31.01
Giza 6 (control)	64.33	36.67	6.17	13.50	14.16	13.33	3.87	29.23	26.96	36.12
M6-13 (20 kr)	64.83	36.67	7.00	19.17	23.90	16.50	7.75	47.59	33.80	33.85
M6-15(1.0*10^{-3} M)	63.00	28.88	6.00	8.83	11.73	9.83	3.94	40.20	37.74	34.17
M6-18 (2.0*10^{-3} M)	61.83	31.38	6.50	19.33	19.66	17.83	9.30	50.97	46.62	28.83
M6-100 (1.0*10^{-3} M)	68.50	31.10	6.00	12.83	12.51	13.17	5.67	42.18	48.36	32.81
NC9 (control)	63.50	28.88	5.33	10.67	10.27	8.00	3.28	38.04	30.45	33.95
M6-30 (1.0*10^{-3} M)	63.50	29.17	5.67	17.00	19.22	17.50	8.57	53.28	43.18	38.96
M6-39/1 (3.0*10^{-3} M)	60.83	33.33	6.17	9.33	11.07	11.50	5.16	44.77	50.80	40.02
M6-74 (2.0*10^{-3} M)	63.17	31.23	6.50	10.17	10.18	11.00	4.21	41.24	44.13	36.74
Revised L.S.D at 5%	2.42	2.15	0.59	1.58	1.65	2.09	0.73	5.64	6.38	1.29

NDF: number of days to 50% flowering; PHt: plant height (cm); NBP: number of branches/plant; NPP: number of pods/plant; PYP: pod yield/plant (g); NSP: number of seeds/plant; SYP: seed yield/plant (g); SI: 100-seed wt. (g); Sh: shelling percentage; Oil: seed oil content (%)

Yield Performance over Control

Pod Yield/plant: It seems clearly that, out of the nine evaluated mutants, three were found to be superior for yield performance. These mutants were M6-13, M6-18 and M6-30, which had shown significantly ($P<0.05$) highest pod yield/plant in both generations and combined over them compared to their check parents and the other mutants. Since, relative increasing over their check parents (control) were 78.62, 34.92 and 93.754% and 59.14, 42.59 and 80.98% in M5 and M6 generations, respectively.



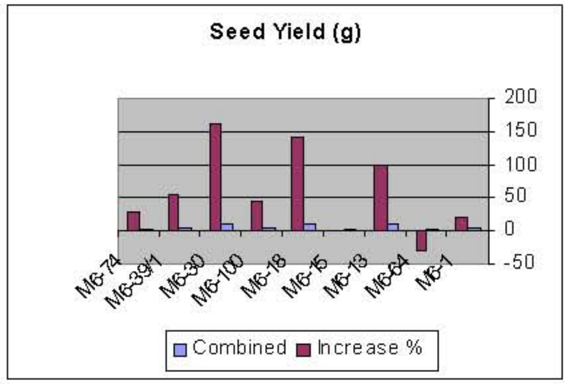


Fig. 1: Increase % of the nine mutants over their parents alongwith their combined performance for pod and seed yield

(A) (B) (C)

Fig. 2: Increase in large seed of the three selected mutants compared to their parents (control)
A. Parent (top) and M6-13 (bottom); B. Parent (top) and M6-18 (bottom); C. Parent (top) and M6-30 (bottom)

Pods/plant: Performances of the evaluated mutants with their chick parents indicate that, the same three mutants; M6-13, M6-18 and M6-30 were produced significantly ($P<0.05$) highest values of pods/plant, but not always significant for the other mutants in M5, M6 generations and their combined. The relative increases over the control were 35.03, 47.56 and 56.23% and 48.72, 38.99 and 62.24% in M5 and M6 generations, respectively.

Seeds/plant: The results indicate that, the same three mutants; M6-13, M6-18 and M6-30 had significant ($P<0.05$) heaviest seeds/plant compared to their chick parents, but not always significant compared to the other mutants in both preliminary trials and their combined. The relative increases over the control were 30.01, 30.01 and 133.38% and 17.55, 37.51 and 104.13% in M5 and M6 generations, respectively.

Seed Yield/plant: Results of seed yield/plant confirmed superiority of the same three mutants; M6-13, M6-18 and M6-30 compared to their chick parents and the others mutants in both preliminary trials and their combined.

Since, it had relative increases over their chick parents were 106.80, 156.42 and 151.05% and 93.10, 123.34 and 172.14% for two preliminary trials, respectively.

100-Seed wt: No differences were recorded in good performance of the three mutants; M6-13, M6-18 and M6-30 in 100-seed weight compared to the above-mentioned traits, since it came in the first by significant increasing over their chick parents, but not always significant for the other mutants in both preliminary trials and their combined. The relative increasing over their chick parents were 66.53, 98.87 and 29.85% and 58.99, 49.97 and 49.86% in both generations, respectively.

Shelling%, Plant Height and No. Of Days to 50% Flowering: In general, mutants; M6-13, M6-18 and M6-30 had good performance in these traits compared to their chick

Seed Oil Content: Results indicated that, M6-30 had significant ($P<0.05$) increasing over their chick parent in each of M5 generation and combined over generations and insignificant increasing in M6 generation, but not always, the best compared to other mutants. With the exception of an insignificant increase of the mutant M6-13 compared to their chick parent in M5 generation, it and the mutant M6-18 has shown decreasing in the values compared to their chick parents.

Consistence over the Two Preliminary Trials: The results show clearly the consistency of performance in the two preliminary trials, especially the three selected mutants; M6-13, M6-18 and M6-30 in most studied traits, indicating that, these mutants were stable and bred true.

DISCUSSION

Through evaluation of the selected mutants in the two preliminary yield trials, combined analysis of them showed that, seasonal differences, were insignificant for all studied traits except for days to 50% flowering and seed oil content which were highly significant and each of branches/plant and seed index which were only significant. These results indicating that, the selected mutants were stable and true breeding during seasons for most studied traits. Furthermore, it could be seen clearly that not all mutants had consistently high yield. Hamid *et al.* [14] have also reported similar results in groundnut. However among these evaluated nine mutants under the salinity condition, performance of the three mutants; M6-13, M6-18 and M6-30 had consistently highest yield in the preliminary trials. This highest in pod yield may be due to the increase in large seed whereas mostly mutants of large seed were accompany with heaviest pod yield. This interpretation emphasizes by the increase in 100-seed wt. for these three mutants compared to their chick parents and the other mutants. In this connection, Sorour *et al.* [12], Mouli and Kale [17] and Sorour [18] have obtained similar mutants with large seed in groundnut.

In addition, performance of these three mutants for most studied traits were consistence over the two preliminary yield trials, indicating that, these mutants are stable and bred true for these traits. Therefore and based on comprehensive consideration of high yielding ability under salinity condition and stability during the preliminary trials, the three mutants; M6-13, M6-18 and M6-30 were selected and must to be put into future advanced yield trials in different locations before registration. The findings obtained in this study were in good agreement to those reported by Badigannavar *et al.* [2], who isolated 91 groundnut true breeding mutants showing salt tolerance by screening plant wise during M4 and M5 generations.

In addition, mutants with high yield were isolated in groundnut by Chandra *et al.* [5], Vuayakumar *et al.* [8], Sorour *et al.* [12], Kale *et al.* [13] and Hamid *et al.* [14]. On the other hand, there were a negative relationship between yield and oil content in these three selected mutants except for, M6-13 in M5 and M6-30 in both M5 and M6 generations. The obtained findings in this study are logic and were in good agreement to those reported by Gadgil and Mitra [19], who observed a negative correlation between oil percentage and seed size but some Trombay groundnut cultures had larger seed as well as more oil.

CONCLUSION

In this study, selection among some isolated promising mutants during M3 and M4 generations and evaluation the selected nine mutants in two preliminary trials were done under salinity condition. The three mutants; M6-13, M6-18 and M6-30 were found to be superior for yield performance and stable during preliminary yield trials. We recommend to put these three mutants into future advanced yield trials in different locations before registration.

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