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S1- FAMILY SELECTION FOR VARIABLE NITROGEN FERTILITY LEVELS IN MAIZE (*Zea mays*, L.).

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ABSTRACT

The present study was carried out at the Agricultural Experiment Station, Alexandria University, Alexandria, during the summer seasons of 2006 and 2007.The main objective of the present study was to; produce a high-yielding populations under variable nitrogen supply through S_1-family selection and determine the correlated responses to selection in yield components and plant characters. In 2004 summer season, an isolated plots of about 0.10 ha was planted with the base population (Alex. 5). Before flowering 300 plants were selected and selfed to produce S_1 seeds. At harvest, the heaviest 90 selfed ears were selected and each ear was considered as an S_1-line. Depending on the results of evaluation trial, the best 10 percent, high yielding S_1-families under each of the three used nitrogen levels (60, 90 and 120 kilograms per faddan) were selected. Saved equal seed numbers of the selected S_1-families under each nitrogen level, were planted during the summer season of 2006 in isolated separate areas, allowed for random matting. Ears of each population were harvested separately to represent the following cycles:

a) *Cycle 1 of S_1-family selection for low nitrogen input designated as* **C_1S_1 (L)]**.
b) *Cycle 1 of S_1-family selection for moderate nitrogen input designated as* **[C_1S_1 M)]**.
c) *Cycle 1 of S_1-family selection for high nitrogen input designated as* **C_1S_1 (H)]**.

In summer season of 2007, the selected cycles, the base population and three check varieties namely; Alexandria 3, Alexandria 4 and Alexandria 6 (synthetics developed by the crop Science Department, Alexandria University) were evaluated in split-plot design experiment, with eight replicates. The main plots received 60, 90 and 120 kilograms nitrogen/faddan. Whereas, the sub-plots received the seven tested populations. At analysis four replicates of heterogenous variances were discarded.

The most important obtained results from this study could be summarized as follows:

1. *Selection under high nitrogen fertility resulted in higher realized gain in ears yield relative to either the base population or the average of checks, irrespective of the fertility level of evaluation site (from 10% to 13%).*
2. *Selection of S_1-lines under low soil fertility gave the least realized gain in ears yield. The realized gain from selection under low soil fertility, was greatly pronounced when the new synthetic was evaluated under low fertility environment (5% over the base population). Also, increasing the fertility of the target environment had adversely affected the attainable realized gain.*
3. *Selection under moderate fertility environment ($C_1S_1(M)$), recorded the highest realized gain of 10 percent of the base population, when evaluated in moderate fertility environment. The response to selection, relative to the average of the checks, followed similar trend, but will lower magnitude.*
4. *The highest realized gain from selection was recorded, when selection was performed under high fertility environment ($C_1S_1(H)$). That synthetic expressed a realized gain*

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reached 12 percent over the base population when evaluated in low fertility environment. Also, the magnitude of that synthetic response to increasing environment fertility, reached 13 percent over the base population in moderate fertility environment. Increasing the fertility of the evaluation environment, adversely affected the magnitude of $C_1S_1(H)$ synthetic to only 10 percent over the base population.

5. *Yield component characters that expressed positive correlated responses to selection, were ear length, ear width and number of kernels per row. Whereas, number of ear's rows and shelling percentage showed very weak correlated response.*
6. *Plant characters that presented positive correlated responses to selection were plant and ear heights. Meanwhile, ear's leaf area, days to 50% silking and days to 50% tasseling had not expressed any clear correlated responses.*

Key words;S_1- Family selection, variable nitrogen fertility, realized gain, correlated response.

INTRODUCTION

Prolificacy and nitrogen fertilizer effects on yield and nitrogen utilization in maize had been investigated (Anderson *et al.*, 1985). Their results indicated that, the ability of a genotype to increase the number of ears per plant and grain yield in response to nitrogen fertility is not necessarily indicative of greater nitrogen utilization efficiency. Genetic selection for ears per plant under low nitrogen fertility may lead to the identification of genotypes with more efficient nitrogen utilization ability, and therefore more efficient grain production. In further work, selection for prolificacy was conducted in the S_1 generation of the parental lines grown with limited nitrogen supply. It resulted in a significant increase in average ears per plant (Moll *et al.*, 1987). They also reported that more ears per plant may be responsible for the higher average nitrogen uptake in the selected material.

Recurrent selection for nitrogen-use efficiency in maize had been reported (Short, 1991). A set of lines were selected *per se* for high yield under both normal and low nitrogen environments and labeled nitrogen-use efficiency (NE). Similarly, a second set was selected for high yield *per se* under both normal nitrogen fertility but with poor yield under low nitrogen fertility. These S_1's were labeled nitrogen-use inefficient (NI). S_1 lines selected as NE were significantly higher yielding *per se* as S_2's in normal and low nitrogen fertility environments when compared to the NI lines. The NE lines of F_{1s} when crossed to two inbred testers were significantly higher yielding in normal nitrogen fertility environments when compared to the NI lines.The relative efficiency of direct selection under low nitrogen *vs.* indirect selection under high nitrogen for improving tropical maize for low-nitrogen target environments had been investigated (Banziger *et al.*, 1997). They reported that, broad-sense heritabilities for grain yield under low nitrogen were average 29% smaller than under high nitrogen, because of lower genotypic variances under low nitrogen. Error variances were similar at low and high nitrogen. Genetic correlations between grain yields under low and high nitrogen were generally positive, where, values were decreased with increasing relative yield reduction under low nitrogen. Selection under high nitrogen for performance under low nitrogen was predicted significantly less efficient than selection under low nitrogen, when, relative yield reduction due to nitrogen stress exceeded 43%. They suggested that, selection gains can be increased if low nitrogen selection environments are included in maize breeding programs targeting such areas.Agronomic performance of maize (*Z. mays* L) breeding lines derived from a low nitrogen maize population had been reported (Kamara *et al.*, 2003). Eighteen S_1 lines of maize derived from a low nitrogen tolerant pool and two inbred lines were evaluated under moderate nitrogen conditions. Their results indicated that, the breeding lines differed in yield, growth, vertical root-pulling resistance, nitrogen-uptake and nitrogen-use efficiency. Breeding lines with high vertical root-pulling resistance took up more nitrogen and utilized it more efficiently. They also showed better agronomic performance and recorded higher yields.

Genetic gains from cycles of full-sib recurrent selection for low nitrogen tolerance in a tropical maize population had been assessed by Omoigui *et al.*, 2006. They reported that, three cycles of full-sib recurrent selection for low nitrogen tolerance resulted in genetic gains of 2.3% and 1.9%. cycle^{-1} grain yield at low and high nitrogen, respectively. Selection also, increased stay-green ability and kernel weight with a corresponding gain of 17.7% and 4.7%. cycles^{-1}, respectively. The observed gain compared favorably well with the expected genetic gain for days to 50% silk, anthesis-silking interval, plant aspect and stay-green. Although, absolute gains were small for grain yield and other secondary traits, the magnitude of changes in the mean of grain yield and other agronomic traits after three cycles of selection suggest that changes in gene frequencies had occurred.

The main objectives of the present study were to;

i) Produce a high-yielding populations under variable nitrogen supply through S_1-family selection.
ii) Determine the correlated responses to selection in yield components and plant characters.

MATERIALS AND METHODS

The present study was carried out at the Agricultural Experiment Station, Alexandria University, Alexandria, during the summer seasons of 2006 and 2007.

Divergent S_1-line selection for nitrogen use-efficiency was examined. The procedure of selection included the following:

S_1-family selection

Depending on the results of evaluation trial (Personal communication), the best 10 percent, high yielding S_1-families under each of the three used nitrogen levels (60, 90 and 120 kilograms per faddan) were selected.

Formation of synthetics

Saved equal seed numbers of the selected S_1-families under each nitrogen level, were planted during the summer season of 2006 in isolated separate areas, allowed for random matting. Ears of each population were harvested separately to represent the following cycles:

d) Cycle 1 of S_1-family selection for low nitrogen input, designated as **[C_1S_1 (L)]**.
e) Cycle 1 of S_1-family selection for moderate nitrogen input, designated as **[C_1S_1 (M)]**.
f) Cycle 1 of S_1-family selection for high nitrogen input, designated as **[C_1S_1 (H)]**.

Cycles Evaluation:

In summer season of 2007, the selected cycles, the base population and three check varieties namely; Alexandria 3, Alexandria 4 and Alexandria 6, (synthetics developed by the **crop Science Department, Alexandria University**), were evaluated in a split-plot design with four replicates. The main plots received 60, 90 and 120 kilograms nitrogen/faddan. Whereas, the sub-plots received the seven tested populations. The form of the analysis of variance is presented in Table (1), assuming that both populations and nitrogen levels were fixed.

Table 1: Form of analysis of variance for cycles evaluation.

Source of variance	D.F.	M.S.	E.M.S
Reps.	3		
Nitrogen (N)	2		
Error (a)	6		
Population (p)	6	M_3	$\sigma^2_e + rn\, K_p^2$
P x N	12	M_2	$\sigma^2_e + r\, K^2_{np}$
Error (b)	54	M_1	σ^2_e

The plot area was 5.6 m^2 representing two rows 4.0 meters long and 0.7 m apart. The experiment was sown in 24th of April, 2007. The studied characters were listed below;

1. Ear yield:

Guarded Harvested ears of each plot were weighted in grams to represent the ear yield/ plot.

2. Yield components:

a. Ear length (cm): measured as an average length of eight ears.
b. Ear width (cm): measured as an average diameter of eight ears.
c. Number of rows/ear: an average of eight ears.
d. Number of kernels/row: average number of grains per ear row of eight ears.
e. Weight of 100 kernels (g): average weight of two samples of 100-kernel each, adjusted to 14% moisture.
f. Shelling percent: measured from eight ear samples taken from each plot as the weight of grains relative to the total weight of ears.
g. Moisture percent: percentage of grain moisture as an average of two samples taken at random from each plot, (Dole 400 tester).

3. Plant characters:

a. Plant height (cm): the distance from soil surface to base of the tassel at full tasseling.
b. Ear height (cm): the distance from soil surface to the node of the upper most ears.
c. Ear leaf area (cm^2): estimated following the equation of Montogomery, 1911 for maize as;
Leaf area (cm^2) = Leaf length (cm) × maximum leaf width (cm) × 0.75
d. Days to mid-tasseling: expressed as the number of days from planting to the day when 50% of the plants had tasseled in each plot.
e. Days to mid-silking: expressed as the number of days from planting to the day when plants had silked in each plot.

RESULTS AND DISCUSSION

The three synthetics developed through the divergent S_1-family selection for nitrogen use efficiency, the base population and three checks namely; Alexandria 3, Alexandria 4 and Alexandria 6 were evaluated in 2007 summer season, under low (60 kg/ faddan), moderate (90 kg/ faddan) and high (120 kg/ faddan) nitrogen regimes. Response to selection in yield of ears, yield components and plant characters were studied. The results obtained for each character will be presented separately.

1- Ears yield:

To correct the differences in moisture content in the different tested populations, the yield of ears adjusted to 14% moisture. The analysis of variance performed for the adjusted yield data. The analysis of variance presented in (Table 2). The variations among the tested populations were highly significant (p≥ 0.01). In addition, the interaction between populations and nitrogen levels was highly significant (p≥ 0.01).

Table (2): Analysis of variance for ear yield of evaluated populations, in 2007 experiment.

Source of variation	d.f.	M.S.
Replication (R)	3	1624475**
Nitrogen (N)	2	2348695**
Error (a)	6	13588
Populations (P)	6	756782**
N × P	12	74679**
Error (b)	54	25891

**** Indicates, significance at 0.01 level of probability.**

Means of ears yield and relative yield to the base population or to the average of check varieties for the different selected populations had presented in (Table 3).Selection under high nitrogen fertility resulted in higher realized gain in ears yield relative to either the base population or the average of checks, irrespective of the fertility level of evaluation site. The realized gain from S_1-line selection under high fertility level ranged from 10 to 13 percent relative to the base population depending on the fertility of evaluation environment. The magnitude of response relative to the average of the checks ranged from three to nine percent.

Selection of S_1-lines under low soil fertility, gave the least realized gain in ears yield. The obtained response ranged from -0.01 to 5 percent of the base population. In the mean time, that realized gain from selection under low soil fertility, had greatly pronounced, when the new synthetic had evaluated under low fertility environment. In addition, increasing the fertility of the target environment had adversely affected the attainable realized gain. It is valuable to notice that the yield of the C_1S_1 (L) synthetic was inferior to the average of the checks, regardless the fertility level of the evaluation environment.

Selection under moderate fertility environment, gave a realized gain in ears yield of intermediate values ranged from eight to 10 percent of the base population. The highest magnitude of response that reached 10 percent of the base population or 6 percent of the average of the checks had obtained when C_1S_1 (M) synthetic evaluated under moderate fertility environment.

Furthermore, selection for high fertility environment (C_1S_1(H)), gave a realized gain of 12 percent over the base population, when evaluated in low fertility environment. Meanwhile, the magnitude of response to selection, reached 13 percent over the base population or 9 percent over the average of the checks, when evaluated in moderate fertility environment. It's valuable to notice that, increasing the fertility of the testing environment, gave lower magnitude of response reached about 10 percent of the base population or 4 percent of the average of the checks.

Table (3): Means and means relative to the base population or to the average of check varieties of ears yield for the different selected populations.

Pedigree	Nitrogen level	Mean yield (g)	Mean relative to	
			C_0	Checks
		Base population		
	60	5175		
Alex. 5 (C_0)	90	5550		
	120	5840		
Average		5522		
		Selected populations		
	60	5451	1.05	0.96
C_1S_1 (L)	90	5665	1.02	0.98
	120	5837	0.99	0.94
Average		5651	1.02	0.96
C_1S_1 (M)	60	5597	1.08	0.99
	90	6157	1.10	1.06
	120	6375	1.09	1.03
Average		6043	1.09	1.03
	60	5818	1.12	1.03
C_1S_1 (H)	90	6300	1.13	1.09
	120	6450	1.10	1.04
Average		6189	1.12	1.05
		Check varieties		
	60	6023		
Alex 3	90	5862		
	120	6345		
	60	5390		
Alex 4	90	5710		
	120	6200		
	60	5462		
Alex 6	90	5737		
	120	5925		
	60	5625		
Average	90	5769		
	120	5850		
Average		5748		
L.S.D.$_{0.05}$(pop×N)		131.7		

Commonly, the highest realized gain from selection was recorded, when selection was performed under high fertility environment (C_1S_1(H)). That synthetic, expressed a realized gain reached 12 percent over the base population, when evaluated in low fertility environment. In addition, the magnitude of that synthetic response to increasing environment fertility, reached 13 percent over the base population in moderate fertility environment. Increasing the fertility of the evaluation environment, adversely affected the magnitude of C_1S_1(H) synthetic to only 10 percent over the base population. Also, selection under low fertility environment (C_1S_1(L)), expressed the highest magnitude of realized gain over the base population (5 percent), when evaluated in low fertility environment. Further increase in the target environment fertility, adversely affected the attainable realized gain (ascending as 2 percent in moderate fertility environment to -1 percent in high fertility environment). Meanwhile, selection under moderate fertility environment (C_1S_1(M)), recorded the highest realized gain of 10 percent of the base population, when evaluated in moderate fertility environment. The response to selection, relative to the average of the checks, followed similar trend, but will lower magnitude, since, the overall average of the checks was superior to the corresponding values of the base population under each respective fertility level.

The obtained results are in agreement with the available review. (Allan and Darrah, 1978) studied the effects of three cycles of reciprocal recurrent selection on the nitrogen and plant population responses of two maize hybrids in Kenya. They found that, significant progress was made from selection in improving the yield of H611(R) (a variety cross of two maize populations improved by reciprocal recurrent selection). The rate of improvement of H611(R) was 8.5% per cycle. (Kamprath *et al.*, 1982) studied the effects of nitrogen fertilization and recurrent selection on performance of hybrid populations of corn. They found that, the improved populations produced more total dry matter and grain at each nitrogen level. The higher yield of the reciprocal recurrent selection at 56 and 168 kg nitrogen/ ha as compared with the full-sib family selection, was associated with higher average nitrogen uptake efficiency. (Lafitte and Edmeades, 1994b) applied a program of full-sib recurrent selection to improve maize grain yield under conditions of low soil nitrogen, while maintaining grain yields under high soil nitrogen, for three cycles in the low land tropical population. They found that, the per cycle linear increase in gain yield under low nitrogen was 2.8% and under high nitrogen was 2.3%, indicating that improved performance at low nitrogen is compatible with yield grain under high nitrogen. (Lafitte and Banziger, 1996) found that, gains over five cycles of full-sib recurrent selection averaged 84 kg grain/ ha/ year (4.5% per year) at low nitrogen and 120 kg grain/ ha/ year (2.3% per year) at high nitrogen. Gains over two to eight selection cycles averaged 100 kg grain/ ha/ year (3.4% per year) at low nitrogen and 75 kg grain/ ha/ year (1.2% per year) at high nitrogen. (Lafitte and Banziger, 1996) applied three cycles of intercrossing as half-sibs in a low nitrogen nursery with very slight selection pressure for ear formation and reduced plant height. The populations under went three additional cycles of improvement with 20-50% selection pressure for yield and plant type under low nitrogen. In two evaluations where nitrogen stress reduced mean yields to 1.05 $t.ha^{-1}$, yields of C_6 of the source populations were not significantly less than the yields of improved check varieties. Yield of the early population increased by 15% per cycle between C_4 and C_6 and that increase was 11% per cycle in the late population. (Sallah *et al.*, 1996) applied recurrent selection to estimate the effectiveness of recurrent selection for improved agronomic performance in the population *La posta* under low levels of applied nitrogen. In anther study, they determined the effects of six cycles of recurrent selection on the nitrogen response of that population. They found that, expected genetic gain per cycle of full-sib selection for grain yield was 4.6% at low nitrogen and 5.0% at high nitrogen. In anther study, between C_0 and C_6 yields increased by 0.26, 0.50 and 0.63 $t.ha^{-1}$ at 0, 80 and 160 $kg.ha^{-1}$ of nitrogen applied, respectively. (Banziger and Lafitte, 1997) found that, direct selection for grain yield was superior to selection for single secondary traits in most experiments, selection efficiency improved by 14% on average, over selection for grain yield alone. (Sallah *et al.*, 1998), improved CIMMYT population 43, improved using six cycles of, full-sib family selection for grain yield and other traits. They found that, grain yields across environments and cycles averaged 3.0, 4.7 and 5.2 $Mg.ha^{-1}$ at 0, 80 and 160 kg $nitrogen.ha^{-1}$, respectively. (Omoigui *et al.*, 2006) applied three cycles of full-sib recurrent selection on a low nitrogen pool-yellow endosperm type maize population. They reported that, three cycles of full-sib recurrent selection for low nitrogen tolerance resulted in a genetic gains of 2.3% and 1.9% grain $yield.cycle^{-1}$ at low and high nitrogen, respectively. (Omoigui *et al.*, 2007) applied three cycles of full-sib recurrent selection on a low nitrogen pool-yellow (LNP-y) maize population. They found that, mean grain yield ranged from 2.5 t/ ha in cycle 1 to 2.7 t/

ha in cycle 3 under low nitrogen and from 4.2 t/ ha in cycle 1 to 4.3 t/ ha in cycle 3 under high nitrogen.

2- Yield components:

Table (4) showed the analysis of variance for yield components characters of the studied populations. The data revealed significant differences ($p \geq 0.01$) among the tested populations in ear length, ear width, rows number per ear, kernels number per row and shelling percentage. Meanwhile, that difference had not reached the level of significance in 100-kernel weight. The interactions between soil fertility level (nitrogen) and the tested populations had found only significant with, ear length, ear width and number of kernels per row. These significant interactions indicate variable response of evaluated populations to the used level of soil fertility.

Table (4): Analysis of variance for yield component traits of evaluated populations in 2007 experiment.

S.O.V	d.f.	Mean squares					
		Ear length (cm)	Ear width (cm)	100-kernel weight (g)	Number of rows/ ear	Number of kernels/ rows	Shelling percent (%)
Replication(R)	3	19.20**	4.784**	20.77*	7.759**	32.95**	31.41**
Nitrogen (N)	2	35.69**	6.406**	10.82$^{n.s}$	9.462**	50.76**	39.48**
Error (a)	6	0.073	0.022	2.779	0.582	0.643	3.126
Population (P)	6	7.590**	1.754**	7.776$^{n.s}$	6.129**	20.99**	19.103**
N × P	12	1.308*	0.274**	1.555$^{n.s}$	0.449$^{n.s}$	1.906*	2.510$^{n.s}$
Error (b)	54	0.554	0.099	1.854	0.495	0.969	2.050

*** and **; indicates significance at 0.05 and 0.01 levels of probability, respectively.**
n.s.; not significantly different.

Means of ear length for the selected populations were presented in (Table 5). The improvement in ear length due to S_1-family selection relative to the base population, reached a maximum of 16% when families were selected in a high fertility environment (120 kg N/ Faddan), then evaluated in a moderate fertility level (C_1S_1 (M) under 90 kg N/ faddan). That improvement was also found the highest, relative to the average of checks, amounting to 13 percent. The correlated response in ear length when S_1-families were selected under low fertility environment (C_1S_1(L)) was more sound, reaching 4% when the new synthetic was evaluated under low fertility environment. In the meantime, S_1-families synthetic that included selected families under moderate fertility environment (C_1S_1(M)), showed better correlated response in ear length relative to the base population (11%) when evaluated in low fertility condition.

As for ear width, (Table 6), the S_1-families synthetics, gained an increase over the base population ranged between 4 and 22%. Low fertility S_1-families synthetic (C_1S_1 (L)), showed the highest correlated response in ear width (4% over the base population), when evaluated in low fertility environment (60 kg N/ faddan). Similarly, moderate fertility synthetic (C_1S_1(M)), expressed a maximum response of 21% over the base population or 12% over the average of the checks, when tested in moderate fertility environment. High fertility synthetic (C_1S_1(H)), showed the largest magnitude of response in ear width when evaluated under moderate fertility environment (22 and 13% over the base population arid the average of the checks, respectively).

Table (5): Means and means relative to the base population or to the average of check varieties of ears length and ear width for the different selected populations.

Pedigree	Nitrogen level	Ears length (cm)			Ears width (cm)		
		Mean	Mean relative to		Mean	Mean relative to	
			C_0	Checks		C_0	Checks
Base population							
Alex. 5 (C_0)	60	14.12			4.087		
	90	15.62			4.587		
	120	16.54			5.137		
Average		15.42			4.603		
Selected populations							
C_1S_1 (L)	60	14.76	1.04	0.97	4.265	1.04	0.90
	90	15.91	1.01	0.98	4.622	1.00	0.93
	120	16.37	0.99	0.92	4.825	0.93	0.84
Average		15.68	1.01	0.96	4.570	0.99	0.89
C_1S_1 (M)	60	15.67	1.11	1.03	4.742	1.16	1.00
	90	17.10	1.09	1.06	5.562	1.21	1.12
	120	17.25	1.04	0.97	5.852	1.13	1.02
Average		16.67	1.08	1.02	5.385	1.16	1.05
C_1S_1 (H)	60	16.17	1.14	1.06	4.687	1.14	0.99
	90	18.24	1.16	1.13	5.640	1.22	1.13
	120	18.79	1.13	1.06	5.757	1.12	1.00
Average		17.74	1.15	1.08	5.361	1.16	1.04
Check varieties							
Alex 3	60	16.53			5.375		
	90	16.15			5.037		
	120	17.83			6.140		
Alex 4	60	14.46			4.235		
	90	15.76			5.000		
	120	18.15			5.702		
Alex 6	60	14.42			4.520		
	90	16.38			4.815		
	120	16.96			5.322		
Average of checks	60	15.13			4.710		
	90	16.09			4.950		
	120	17.64			5.720		
Average		16.29			5.127		
L.S.D.$_{0.05}$(pop×N)		0.609			0.2579		

The correlated response in 100-kernel weight of S_1-family synthetics was of very small and unsignificant magnitude **(Table 6)**. It's valuable to notice that, the differences in that character was unsignificantly affected by neither the fertility level nor the interaction between fertility and populations. This might due to the high magnitude of correlated error during sampling and measuring.

Concerning the number of rows per ear **(Table 6)**, S_1-family selection resulted in a significant increase of 8%, relative to over the base population or 2% relative to the average of the checks, when the families were selected in a moderate fertility environment (C_1S_1 (M)). That magnitude of response was not significantly different from the figure obtained with high fertility synthetic (9 and 4%, relative to over the base population and the average of the checks, respectively). It is valuable to notice that, selection of S_1-families in low fertility environment, had no result in improving the new synthetic (C_1S_1(L)) number of rows/ ear.

Table (6): Means and means relative to the base population or to the average of check varieties of 100-kerenl weight and No. of rows/ ear for the different selected populations.

Pedigree	Nitrogen level	100- kernel weight (g)			No. of rows/ ear		
		Mean	Mean relative to		Mean	Mean relative to	
			C_0	Checks		C_0	Checks
Base population							
Alex. $_5$ (C_0)	60	28.64			13.57		
	90	29.17			14.70		
	120	29.93			15.23		
Average		29.25			14.50		
Selected populations							
C_1S_1 (L)	60	28.21	0.98	0.96	13.64	1.00	0.92
	90	29.06	0.99	0.98	14.29	0.97	0.93
	120	29.16	0.97	0.95	14.58	0.95	0.92
Average		28.81	0.98	0.96	14.17	0.98	0.92
C_1S_1 (M)	60	29.36	1.02	1.00	14.51	1.06	0.98
	90	30.62	1.04	1.03	15.82	1.07	1.03
	120	31.36	1.04	1.02	16.44	1.07	1.03
Average		30.45	1.04	1.02	15.59	1.08	1.02
C_1S_1 (H)	60	28.87	1.00	0.98	15.67	1.15	1.06
	90	29.97	1.02	1.01	16.12	1.09	1.05
	120	30.00	1.00	0.98	15.79	1.03	0.99
Average		29.61	1.01	0.99	15.86	1.09	1.04
Check varieties							
Alex $_3$	60	31.26			15.81		
	90	29.73			15.95		
	120	32.07			16.43		
Alex $_4$	60	28.48			14.08		
	90	29.59			14.91		
	120	28.84			15.59		
Alex $_6$	60	28.35			14.19		
	90	29.49			14.99		
	120	30.55			15.42		
Average of checks	60	29.360			14.69		
	90	29.6			15.28		
	120	30.48			15.81		
Average		29.81			15.26		
L.S.D.$_{0.05}$(pop×N)		n.s.			0.398		

Number of kernels per row (Table 7) showed significant response to selection environment-fertility and evaluation environment-fertility. S_1-family synthetic for low soil fertility (C_1S_1(L)) expressed the highest response to selection (5% relative to the base population) when evaluated in low nitrogen input (60 kgN/ faddan), whereas, moderate nitrogen-input synthetic (C_1S_1(M)), showed the highest gain in number of kernels/ row (12 and 6% relative to the base population and the average of the checks, respectively) in moderate nitrogen-input (90 kgN/ faddan). Furthermore, selection of S_1-families under high nitrogen-input gave the largest magnitude of response in number of kernels/ row (14 and 8% over the base population and the average of the checks respectively), under moderate nitrogen-input (90 kgN/ faddan).

Shelling percentage (Table 7) affected significantly by the nitrogen input that affect the fertility of selection environment. S_1-family synthetic for low nitrogen input (C_1S_1(L)) recorded 1% gain in shelling percent over the base population. While, moderate nitrogen input synthetic, gave significantly higher magnitude of response reached 3% over the base population. The gain from selection for high nitrogen input synthetic (C_1S_1(H)), significantly reached 4% over the base population. It is valuable to indicate that, the gain from selection was not significantly affected by variation in test environment fertility (nitrogen input level).

Changes in secondary characters correlated with yield are of considerable importance to plant breeders, since, the selected populations must have considerable agronomic traits beside high yield. Change in secondary characters upon selection for yield can be more effective if genetic correlation and heritability of such traits are both high.

Table (7): Means and means relative to the base population or to the average of check varieties of Number of kernels/ row and shelling percent for the different selected populations.

Pedigree	Nitrogen level	No. of kernels/ row			Shelling percent (%)		
		Mean	Mean relative to		Mean	Mean relative to	
			C_0	Checks		C_0	Checks
Base population							
	60	26.08			77.00		
Alex. 5 (C_o)	90	27.75			78.38		
	120	29.21			78.95		
Average		27.67			78.11		
Selected populations							
	60	27.53	1.05	0.96	78.56	1.02	0.98
C_1S_1 (L)	90	28.38	1.02	0.97	79.05	1.00	0.99
	120	28.68	0.98	0.92	79.38	1.00	0.97
Average		28.19	1.018	0.95	79.00	1.01	0.99
	60	27.96	1.07	0.98	78.48	1.01	0.98
C_1S_1 (M)	90	31.24	1.12	1.06	81.00	1.03	1.02
	120	31.87	1.09	1.02	82.35	1.04	1.00
Average		30.36	1.09	1.02	80.61	1.03	1.00
	60	29.24	1.12	1.02	79.68	1.03	1.00
C_1S_1 (H)	90	31.67	1.14	1.08	81.90	1.04	1.03
	120	32.44	1.11	1.04	82.95	1.05	1.01
Average		31.12	1.12	1.05	81.51	1.04	1.02
Check varieties							
	60	30.25			81.30		
Alex 3	90	29.87			80.43		
	120	32.13			82.45		
	60	27.83			78.70		
Alex 4	90	28.57			79.35		
	120	30.70			81.50		
	60	27.38			78.70		
Alex 6	90	29.16			78.25		
	120	30.06			81.25		
	60	28.48			79.56		
Average of checks	90	29.12			79.34		
	120	30.96			81.73		
Average		29.55			80.21		
L.S.D.$_{0.05}$(pop×N)		0.806			0.810		

Commonly, yield component characters that expressed positive correlated responses to selection, were ear length, ear width and number of kernels per row. Whereas, number of ears rows and shelling percentage showed very weak correlated response.

(Kamprath *et al.*, 1982) studied the effects of nitrogen fertilization and recurrent selection on performance of hybrid populations of corn. They found that, an increase in the ear number per plant as the nitrogen rate increased. (Lafitte and Edmeades, 1994b) applied a program of full-sib recurrent selection to improve maize grain yield under conditions of low soil nitrogen, while maintaining grain yields under high soil nitrogen for three cycles in the low land tropical population. They found that, increased grain yields were associated with significant linear increases per cycle, measured a cross nitrogen levels, in kernels.ear^{-1}. (Lafitte and Edmeades, 1994c) used four cycles of recurrent selection to identify the possible causes of increased variation in grain yield with selection for tolerance to low soil nitrogen. They found that, by C_3, the number of kernels.plant^{-1} had been increased. (Below *et al.*, 1996) studied the combining ability for nitrogen use in maize on fifteen single-cross hybrids of maize. They found that, kernel number was positively correlated with grain yield when plants were grown at low nitrogen. (Medici *et al.*, 2005) studied one S_4 and seven S_5 lines originating from two commercial hybrids for agronomic traits related to nitrogen-use efficiency. They found that, severe nitrogen deficiency caused an increase in 100-kernel weight in line 2. (Omoigui *et al.*, 2006) conducted three cycle of full-sib recurrent selection for low nitrogen tolerance in a tropical maize population. They found that, selection increased kernel weight with a corresponding gain of 4.7% cycle^{-1}.

3- Plant characters:

Mean squares of plant characters i.e.; plant height, ear height, ear leaf area, silking and tasselling dates were presented in (Table 8). Differences among the tested populations were significantly different for all studied plant characters. The interaction between populations and nitrogen levels were only significant for plant and ear height.

Table (8): Analysis of variance for plant characters traits for different characters of evaluated populations in 2007 experiment.

S.O.V	d.f.	Mean squares				
		Plant height (cm)	**Ear height (cm)**	**Ear leaf area (cm^2)**	**50% silking**	**50 % Tasselling**
Replication(R)	3	2201**	569.46**	20604**	36.04$^{n.s}$	15.19$^{n.s}$
Nitrogen (N)	2	3906**	996.0**	17169**	27.46$^{n.s}$	7.69$^{n.s}$
Error (a)	6	40.87	11.68	563.3	23.73	5.671
Population (P)	6	1309**	333.0**	15692**	14.97	3.880*
N × P	12	130.69**	40.98**	2004$^{n.s}$	7.686$^{n.s}$	0.459$^{n.s}$
Error (b)	54	50.36	15.23	1203	6.559	1.530

*** and **; indicate significance at 0.05 and 0.01 levels of probability, respectively.**
n.s.; not significantly different.

Means of plant height for the studied populations were presented in (Table 9), correlated responses in plant height of selected populations relative to the base population varied from 1 to 15 percent. The highest gain in plant height of low nitrogen input synthetic (C_1S_1(L)) was expressed when the synthetic was evaluated in low nitrogen input environment (5% relative to the base population). The same was true with moderate nitrogen input synthetic (C_1S_1(M)), where, the highest gain in plant height was recorded at moderate fertility environment (12 and 8% relative to the base population and the average of the checks, respectively). Meanwhile, the gain in high nitrogen input synthetic (C_1S_1(H)) was greatly realized in low nitrogen environment (15% relative to the base population.

Means of ear height for the studied population under different nitrogen levels were illustrated in (Table 9). Correlated response in ear height of the new synthetic, relative to the base population were recorded. The low nitrogen input synthetic (C_1S_1(L)), gave 5% higher ears when evaluated in low fertility environment. While, the moderate nitrogen-input synthetic (C_1S_1(M)), showed gradual increase in ear height gain with increasing nitrogen input (7, 10 and 13% relative to the base population). Meanwhile, the high nitrogen-input synthetic (C_1S_1(H)), had 15% higher ears relative to the base population when evaluated under both low and high nitrogen input.

Table (9): Means and means relative to the base population or to the average of check varieties of plant height and ear height for the different selected populations.

Pedigree	Nitrogen level	Plant height (cm)			Ear height (cm)		
		Mean	Mean relative to		Mean	Mean relative to	
			C_o	Checks		C_o	Checks
		Base population					
	60	171.0			86.75		
Alex. $_5$ (C_o)	90	188.0			95.50		
	120	196.0			98.00		
Average		185.0			93.41		
		Selected populations					
	60	180.0	1.05	0.95	91.25	1.05	0.96
C_1S_1 (L)	90	187.0	0.99	0.95	93.50	0.97	0.95
	120	198.0	1.01	0.94	98.75	1.00	0.93
Average		188.3	1.01	0.95	94.50	1.01	0.95
	60	186.0	1.08	0.98	93.00	1.07	0.98
C_1S_1 (M)	90	212.0	1.12	1.08	105.5	1.10	1.07
	120	218.0	1.11	1.03	110.8	1.13	1.04
Average		205.3	1.103	1.03	103.1	1.10	1.03
	60	198.0	1.15	1.04	100.0	1.15	1.05
C_1S_1 (H)	90	214.0	1.13	1.09	107.8	1.12	1.09
	120	222.0	1.13	1.05	113.3	1.15	1.06
Average		211.3	1.14	1.060	107.0	1.140	1.07
		Check varieties					
	60	207.0			103.5		
Alex $_3$	90	199.0			98.50		
	120	218.0			111.3		
	60	180.0			90.75		
Alex $_4$	90	195.0			97.50		
	120	212.0			106.3		
	60	179.0			90.00		
Alex $_6$	90	193.0			98.75		
	120	200.0			100.5		
	60	188.7			94.75		
Average of checks	90	195.7			98.25		
	120	210.0			106.0		
Average		198.1			99.66		
L.S.D.$_{0.05}$(pop×N)		5.808			3.197		

As for ear leaf area (Table 10), S_1-family selection for low nitrogen input, resulted in an increase of about 8% over the base population. S_1-family synthetics for moderate and high nitrogen input, gave substantial increase in ear leaf area reached 12 and 17% of the base population. The rate of response in ear leaf area was not affected by the level of nitrogen in the test environment.

Means of days to 50% silking of the studied populations (Table 10) followed similar trend to that obtained with days to 50% tasselling.

Concerning the flowering dates, means of day to 50% tasselling of the tested populations were recorded in (Table 10). S_1-family selection for low nitrogen input was encountered with 2% delay in tasselling relative to the base population. Meanwhile, synthetic formulated for moderate or high nitrogen input, had not showed any change in tasselling dates.

Commonly, plant characters that presented positive correlated responses to selection were plant and ear heights. Meanwhile, ear's leaf area, days to 50% silking and days to 50% tasseling had not expressed any clear correlated responses.

Correlated response in plant characters are very useful for attaining the crop-plant idio type that match various economic and cultural requirements. The correlated responses in plant characters were differently cited. (Lafitte and Edmeades, 1994b), (Sallah *et al.,* 1996), (Sallah *et al.,* 1998).

Table (10): Means and means relative to the base population or to the average of check varieties of ear leaf area, 50% silking and 50% tasselling for the different selected populations.

Pedigree	Nitrogen level	ear leaf area(cm^2)			50% silking			50% tasselling		
		Mean	Mean relative to		Mean	Mean relative to		Mean	Mean relative to	
			C_0	Checks		C_0	Checks		C_0	Checks
Base population										
	60	560.0			72.50			65.75		
Alex. 5 (C_0)	90	577.0			74.00			64.50		
	120	593.0			72.50			65.00		
Average		576.7			73.00			65.08		
Selected populations										
	60	589.0	1.05	0.90	73.50	1.01	1.04	67.38	1.02	1.02
C_1S_1 (L)	90	618.0	1.07	0.96	73.50	0.99	1.02	65.88	1.02	1.00
	120	661.0	1.11	0.95	73.25	1.01	1.04	65.50	1.00	1.01
Average		622.7	1.08	0.94	73.42	1.00	1.03	66.25	1.00	1.01
	60	654.0	1.16	1.00	75.00	1.03	1.06	65.25	0.99	0.99
C_1S_1 (M)	90	617.0	1.06	0.96	72.25	0.97	1.01	65.00	1.00	0.99
	120	673.0	1.13	0.97	73.50	1.01	1.04	64.75	0.99	1.00
Average		648.0	1.12	0.98	73.60	1.01	1.04	65.00	1.00	0.99
	60	632.0	1.12	0.97	73.50	1.01	1.04	65.25	0.99	0.99
C_1S_1 (H)	90	694.0	1.20	1.80	70.75	0.95	0.98	64.75	1.00	0.99
	120	711.0	1.19	1.03	75.25	1.03	1.07	64.50	0.99	0.99
Average		679.0	1.17	1.02	73.17	1.00	1.03	64.83	0.99	0.99
Check varieties										
	60	703.0			72.00			66.00		
Alex 3	90	640.0			73.50			65.75		
	120	707.0			72.00			65.00		
	60	618.0			70.00			66.25		
Alex 4	90	644.0			70.75			66.00		
	120	684.0			70.00			65.00		
	60	630.0			69.00			65.25		
Alex 6	90	640.0			70.25			64.00		
	120	676.0			69.00			64.00		
	60	650.3			70.33			65.83		
Average of checks	90	641.3			71.50			65.25		
	120	689.0			70.33			64.66		
Average		660.2			70.72			65.25		
L.S.D.$_{0.05}$(pop×N)		28.39			2.096			1.012		

In Conclusion;

Increasing the ears yield of a new synthetic by 50% under low fertility environment requires about 10 cycles of S_1-family selection, with families evaluated under low nitrogen fertility levels.

a- Increasing the ears yield of a new synthetic by 50% under low fertility environment, requires 6 cycles of S_1-family selection, with families evaluated under moderate nitrogen fertility levels or after 5 cycles of S_1-family selection when the target environment is of moderate nitrogen fertility.

b- The ears yield of a new synthetic might be increased by 50% in low or moderate nitrogen fertility environment, after 4 cycles of S_1-family selection, assuming that the families were selected under high nitrogen fertility environment.

c- Commonly, yield component characters that expressed positive correlated responses to selection, were ear length, ear width and number of kernels per row. Whereas, number of ear's rows and shelling percentage showed very weak correlated response.

d- Commonly, plant characters that presented positive correlated responses to selection were plant and ear heights. Meanwhile, ear's leaf area, days to 50% silking and days to 50% tasseling had not expressed any clear correlated responses.

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الملخص العربي

انتخاب عائلات الجيل الأول للتلقيح الذاتي لمستويات متنوعة من التسميد الازوتى في الذرة الشامية

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تمت الدراسة الحالية علي محصول الذرة الشامية بمحطة البحوث الزراعية التابعة لجامعة الإسكندرية، بالإسكندرية خلال موسم الصيفي للسنوات ٢٠٠٦ و ٢٠٠٧ إنتاج عشائر عالية الإنتاج تحت ظروف التسميد الأزوتي المحدود من خلال إستخدام عائلات الجيل الأول للتلقيح الذاتي (S_1).وإعتماداً علي نتائج تقييم العائلات، تم إنتخاب أعلي ١٠% من العائلات من حيث محصول الكيزان تحت كل مستوي من مستويات الأزوت المستخدمة (٦٠ و ٩٠ و ١٢٠ كيلوجرام للفدان).

خلطت أعداد متساوية من حبوب العائلات المنتخبة تحت كل مستوي من مستويات الأزوت، وزرعت في مناطق معزولة منفصلة خلال موسم صيف ٢٠٠٧ حيث تركت للتلقيح العشوائي، ثم حصدت كيزان كل عشيرة جديدة علي حدة لتمثل العشائر التالية:-

أ- الدورة الأولي الناتجة عن إنتخاب عائلات الجيل الأول للتلقيح الذاتي تحت ظروف التسميد الأزوتي المنخفض ويمثلها الرمز C_1 S_1 (L).

ب- الدورة الأولي الناتجة عن إنتخاب عائلات الجيل الأول للتلقيح الذاتي تحت ظروف التسميد الأزوتي المتوسط ويمثلها الرمز C_1 S_1 (M).

ج- الدورة الأولي الناتجة عن إنتخاب عائلات الجيل الأول للتلقيح الذاتي تحت ظروف التسميد الأزوتي العالي ويمثلها الرمز $C_1\ S_1\ (H)$.

خلال موسم صيف ٢٠٠٧ تم تقييم العشائر الثلاث المنتخبة مع عشيرة الأساس (إسكندرية ٥) وثلاثة عشائر إختبارية (إسكندرية ٣ و إسكندرية ٤ و إسكندرية ٦) في تصميم قطع منشقة لمرة واحدة من ثمان مكررات. القطع الرئيسية خصصت لمستويات من التسميد الأزوتي (٦٠ و ٩٠ و ١٢٠ كجم أزوت للفدان) بينما خصصت القطع الفرعية للعشائر المختبرة. عند تحليل النتائج إستبعدت ٤ مكررات نظراً لعدم تجانس تباينها. وقد تم دراسة صفات محصول الكيزان بالجرام ومن مكونات المحصول تم دراسة صفات طول الكوز (سم) وعرض الكوز (سم) ووزن الـ ١٠٠ حبة (جرام)، عدد الصفوف/ كوز وعدد الحبوب/ صف والنسبة المئوية للتفريط ومن الصفات النباتية تم دراسة صفات إرتفاع النبات (سم)، ارتفاع الكوز (سم)، مساحة ورقة الكوز (سم^2)، وعدد الأيام حتى ظهور النورة المؤنثة ٥٠% من النباتات وعدد الأيام حتى ظهور النورة المذكرة من ٥٠% من النباتات، ويمكن تلخيص أهم النتائج المتحصل عليها في التالي:-

١- الإنتخاب تحت مستوي الأزوت المرتفع نتجت عنه أعلي إستجابة في محصول الكيزان منسوبة إلي عشيرة الأساس أو متوسط الأصناف الإختبارية، وذلك بغض النظر عن مدي خصوبة بيئة الإختبار.

٢- نتج عن إنتخاب عائلات الجيل الأول للتلقيح الذاتي تحت ظروف التسميد الأزوتي المنخفض، أقل إستجابة في محصول الكيزان. وقد كانت الإستجابة للإنتخاب أعلي وضوحاً عند تقييم العشيرة المحسنة تحت ظروف الخصوبة المحدودة (بلغت ٥% أعلي من عشيرة الأساس). وقد إنخفضت قيم الإستجابة للإنتخاب عند تقييم العشيرة المحسنة الجديدة تحت مستويات خصوبة أعلي من تلك التي تم الإنتخاب فيها.

٣- الإنتخاب تحت مستوي خصوبة متوسط، سجل أعلي إستجابة للإنتخاب بلغت ١٠% من عشيرة الأساس عندما تم تقييم العشيرة المحسنة الجديدة تحت ظروف خصوبة متوسطة وذلك منسوباً لأي من عشيرة الأساس أو متوسط الأصناف الإختبارية.

٤- أعلي إستجابة للإنتخاب نتجت عندما تم الإنتخاب في بيئة عالية الخصوبة، وقد سجلت العشيرة المحسنة الجديدة زيادة في المحصول بلغت ١٢% من عشيرة الأساس وذلك عند تقييمها في ظروف الأزوت المحدود. وقد إستجابت العشيرة الجديدة لزيادة مستوي خصوبة التربة من الأزوت إلي المستوي المتوسط حيث بلغت الإستجابة ١٣%. ولكن قيم الإستجابة للإنتخاب مع زيادة الأزوت إلي المستوي المرتفع إنخفضت إلي ١٠% من عشيرة الأساس.

٥- كانت صفات مكونات المحصول التي أظهرت إستجابات موجبة مرتبطة بالإنتخاب لصفة المحصول ممثلة بكل من طول الكوز وعرض الكوز وعدد الحبوب في الصف، بينما أظهرت صفات عدد الصفوف بالكوز ونسبة التفريط إستجابات مرتبطة ضعيفة.

٦- الصفات النباتية التي أظهرت إستجابة موجبة مرتبطة بالإنتخاب لصفة المحصول كانت ممثلة بكل من إرتفاع النبات والكوز بينما لم تظهر أى إرتباطات موجبة في صفات مساحة ورق الكوز وعدد الأيام حتي ظهور الحريرة أو الشرابة في ٥٠% من النباتات.

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