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REGISTRATION AND RELEASING OF TWO NEW YELLOW HYBRIDS OF MAIZE IN EGYPT

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ABSTRACT

Three yellow promising crosses (SC Sk126, SC Sk130 and SC Gz304) and two checks (SC162 and SC168) were evaluated in three trials, the first trial (B) for estimating grain yield at five research stations, the second trial (C) to estimate resistance to late wilt disease under artificial infestation at four research stations and the third trial (D) to estimate grain yield in farmers fields at eleven governorates during the period from 2018 to 2021. In that respect, the two promising hybrids (SC Sk126 and SC Sk130) were superior in both grain yield and stability as well as in resistance to late wilt disease. They also passed from distinction, uniformity and stability test (DUS). Consequently, the two hybrids have fulfilled all the Egyptian cross registration tests. Thus, they were registered as new commercial hybrids. The hybrid SC Sk126 was commercially named SC181 and the hybrid SC Sk130 was commercially named SC182.

Key words: ***Zea mays* L., *Single crosses, Distinguish, Uniformity, Stability parameters.***

INTRODUCTION

In Egypt, maize (*Zea mays* L.) is one of the most important cereal crops grown. It ranks the second amongst cereal crops with regard to planting area and production after wheat. In 2021, maize was grown in 2.8 million faddan and produced 9.2 million ton. However, the local production of maize is sufficient for nearly 48-50% from the consumption. To narrowing the gap between local production and consumption of maize, the total area and the grain yield per unit area should be increased. In Egypt, successful new hybrids must show high performance for yield and other essential agronomic traits. Moreover, their superiority should be reliable across a wide range of environmental conditions, Becker and Leon (1988) stated that plant breeders generally agree on the importance of high yield stability, but there is less agreement on the most appropriate definition of stability and on the methods to measure and to improve yield stability. To select broadly adapted and stable genotypes, information dealing with adaptation of genotype and stability across environments is important. Identification of stable genotypes that show the least genotype × environment interaction (GEI) is an important consideration in sites with noticeable environmental fluctuations. To calculate GEI, breeders evaluate genotypes across a vast range of environments to identify high yielding and stable genotypes. Genotypes with no GEI are considered stable genotypes (Ssemakula and Dixon 2007). GEI can be grouped into two broad categories: crossover and non-crossover interactions; the differential response of cultivars to diverse environments is referred to as a crossover interaction when cultivar rank change from one environment to another. A main feature of crossover interaction is intersecting lines in a graphical representation. If the lines do not intersect, there is no crossover interaction (Kang 1998). In crop breeding, the crossover interaction is more important than non-crossover interaction (Baker 1990). Lack of crossover interaction for quantitative trait loci (QTL) even in the presence of significant GEI has been reported (Lee 1995 and Beavis and Kein 1996). Obviously the cost of cultivar evaluation increases as additional testing is carried out. However, with additional test environments, breeders and agronomists can identify cultivars with specific adaptation as well as those with broad adaptation, which will not be possible from testing in a single environment. Broad adaptation provides stability against the variability inherent in an ecosystem, but specific adaptation may provide a significant yield advantage in particular environments (Wade *et al* 1999). Stability of performance can be ascertained *via* stability statistics (Lin *et al* 1986, Kang 1990 and Kang and Gauch 1996). To be reliable a stability statistic must be based on a large number of environments (more than ten). Information on stability can usually be obtained in the final stages of breeding program, when replicated tests are conducted (Kang 2002).

The objective of this study was to identify maize hybrids that have both high grain yield and stable performance across different environments in Egypt as well as resistance to late wilt disease.

MATERIALS AND METHODS

According to maize hybrids registration protocol in Egypt, new maize hybrids must successfully pass from the two tests, *i.e.* Value for Cultivation and Use (VCU) and distinguish, uniformity and stability test (DUS).

Value for Cultivation and Use test (VCU)

Any new maize hybrids should be tested for three trials, the first trial (B) to estimating grain yield at five research stations *i.e.* Sakha, Gemmeiza, Sids, Mallawi and Nubaria, the second trial (C) for resistance to late wilt disease under artificial infestation at four research stations *i.e.* Sakha, Gemmeiza, Sids and Mallawi and the third trial (D) for grain yield in farmers' fields at eleven locations (governorates).

Plant materials used in this investigation included three yellow promising single crosses *i.e.* SC Sk126, SC Sk130 and SC Gz304. The promising hybrids SC Sk126, SC Sk130 passed from B-trial in 2018 season, while SC Gz304 passed from B-trial in 2019 season. B-trial included promising crosses and two commercial yellow single crosses (SC162 and SC168). In 2020 season, the above three promising hybrids successfully passed from C-trial. In 2021 season, the three promising hybrids SC Sk126, SC Sk130 and SC Gz304 and the two checks (SC162 and SC168) were grown in farmers' field (D) trial. This trial was the last evaluation stage of new maize hybrid registration at eleven locations or governorates across Egypt, *i.e.* Behera, Kafr El-Sheikh, Dakahlia, Gharbia, Menufiya, Sharkia, Giza, Beni-Suef, Minia, Assiut, and Sohag. The experimental design at each location was a randomized complete block with four replications in B-trial and six replications in and C and D-trials. Each plot for all trials (B, C and D) consisted of four rows, 6 m in length, with a spacing of 0.80 m in B and C-trials and 0.70 m between the rows in D-trial and 0.25 m between hills in all trials. Managements of fertilization and crop treatments were performed based on expectations of high yield. The fertilizer was applied at planting using 30 kg of P_2O_5 and 24 kg of K_2O per feddan. Besides the nitrogen fertilizer was applied at the rate of 120 kg N/fed splitted into two equal doses and was added before the first and second irrigation in urea form (46.5%). The internal two rows of each plot were harvested and yield in ardab per feddan (ard/fed) was measured based on 15.5% of grain moisture in B and D-trials. Also the internal two rows of each plot were used to estimate resistance to late wilt disease in C-trial. The statistical analysis was done at each location and the combined analysis across locations was done after the homogeneity test according to Snedecor and Cochran (1967). Calculation of analysis of variances and Fisher's protected LSD test were carried out by using computer application of statistical analysis system (SAS-institute Inc. 1999). Stability parameters were performed in D-trial according to Eberhart and Russell (1966) to estimates both regression coefficient (b_i) and mean deviation from regression (S^2d_i), Pinthus (1973) to estimate coefficient of determination (R^2), Wricke (1962) to estimate covalence (W_i^2) and Lin and Binns (1988) to estimate superiority measure (P_i). Stability parameters were performed using GEA-R (Genotype × Environment Analysis with R for windows) 2017.

Distinguish, uniformity and stability test (DUS).

The morphological characteristics were performed by the Central Administration of Seed Certification (CASC) according to the International Union for the Protection of New Varieties of Plants (UPOV). This test was carried out during 2020 and 2021 seasons.

RESULTS AND DISCUSSION

VCU tests

1. B-trial:

Mean performance of three promising crosses and two checks for grain yield are shown in Table 1. The promising hybrids SC Sk126 significantly outyielded the two checks SC162 and SC168. In addition the grain yield of promising hybrid SC Sk130 was increased significantly as compared to SC168 but not significantly with SC162. Meanwhile, SC Gz304 was not significantly with the two checks. According to maize registration rules in Egypt, the three promising hybrids could be recommended to move up to the second stage of the evaluation (C-trial).

Table 1. Mean grain yield of three promising crosses and two checks across five locations in 2018 and 2019 seasons.

Hybrid	Grain yield (ard/fed)	
	2018	2019
SC Sk-126	31.53	-
SC Sk-130	29.68	-
SC Gz-304	-	28.31
SC 162	28.29	29.00
SC 168	27.40	29.51
LSD 0.05	1.80	1.44

2. C-trial:

Percentage of resistance to late wilt disease for three promising crosses under artificial infection by late wilt disease at four locations is presented in Table 2. The three promising crosses had a percentage of resistance over 90% under all locations. Therefore they enter into the following experiments (D-trial).

Table 2. Percentage of resistance to late wilt for three promising crosses under artificial infection by late wilt disease at four locations in 2020 season.

Hybrid	% resistance to late wilt disease			
	Sakha	Gemmiza	Sids	Mallawi
SC Sk-126	99	96	94	100
SC Sk-130	100	98	96	92
SC Gz-304	100	98	96	99

3. D-trial:

Combined analysis of variance for grain yield of the three promising crosses is presented in Table 3. Highly significant mean squares were shown among locations (L), meaning that these locations represented a wide range of differences in their climatic and soil conditions, which explained 88.32% of the total variance (L, H and HL). The mean squares due to hybrids (H) were highly significant, indicating that the differences among hybrids were existing among them and the presence of genetic background differences among hybrids for grain yield, which explained 1.55% of the total variance.

The mean squares due to hybrids × locations interaction was highly significant, suggesting that hybrids behaved differently under different locations, this interaction represents about 10.13% of the total variance. These results are in agreement with Kaya and ozer (2014) they showed that grain yield was significantly affected by E which explained 88.6% of the total variation (G+E+GEI), whereas for G and GEI, they accounted for 3.2% and 8.3%, respectively. Shojaei *et al* (2021) found that genotypes (G), locations (L) and their interaction GL were found to be significant for grain yield.

Table 3. Analysis of variance for three promising crosses and two checks for grain yield across 11 locations in 2021 season.

SOV	df	Grain yield		Explained%
		S.S.	M.S.	
Location (L)	**10**	**9020.74**	**902.07****	**88.32**
Rep/L	**55**	**1033.95**	**18.79**	
Hybrid (H)	**4**	**158.12**	**39.53****	**1.55**
H×L	**40**	**1034.32**	**25.85****	**10.13**
Error	**220**		**9.36**	

**** Significant at 0.01 level of probability.**

Mean performance for the three promising hybrids and their superiority relative to checks for grain yield across 11 locations are presented in Table 4. The best promising hybrid was SC Sk126 (33.06 ard/fed) followed by SC Sk130 (32.03 ard/fed) and SC Gz304 (31.06 ard/fed). The hybrids SC Sk126 and SC Sk130 were not significantly for % superior to the best check SC168, therefore, they can be registered as new commercial hybrids according to maize registration rules in Egypt.

Table 4. Mean performance for three promising hybrids and their superiority relative to checks for grain yield across 11 locations.

Hybrid	Mean (ard/fed)	% Superiority relative to checks	
		SC 168	SC 162
SC Sk-126	**33.06**	**1.07**	**3.44***
SC Sk-130	**32.03**	**-2.10**	**0.18**
SC Gz-304	**31.06**	**-5.04***	**-2.81**
LSD 0.05	**1.00**		

*** Significant at 0.05 level of probability.**

Simultaneous selection for grain yield and stability of performance are an important consideration in breeding programs. Therefore, the stability of these hybrids was estimated by a number of statistical parameters.

Estimates of stability parameters of the five studied hybrids for grain yield are presented in Table 5. Based on regression coefficient (b_i), the four hybrids SC Sk126, SC Sk130, SC162 and SC168 were not significantly different from 1.0 while SC Gz304 was significantly different (<1.0). Thus, all hybrids except SC Gz304 can be considered stable for grain yield. Also all hybrids except SC162 had deviation from regression (S^2d_i) values not significantly different from 0, hence according to S^2d_i SC Sk126, SC Sk130, SC Gz304 and SC168 could be considered stable. Eberhart and Russell (1966) identified a desirable genotype as one with a high mean yield, b=1 and S^2d_i=0. Consequently the hybrids SC Sk126, SC Sk130, and SC168 were desirable in yield and stability. The coefficient of determination (R^2) according to Pinthus (1973) considered as stability parameter, the genotypes with the higher values (nearly to 1) are considered stable, so the hybrids SC Sk126 followed by SC168, SC Gz304 and SC Sk130 were stable. However, the three hybrids SC Sk126, SC168 and SC Sk130 were stable and revealed the highest grain yield. Wricke (1962) suggested that the stable genotype should be the one with the lowest ecovalence (W_i^2), indicating that the hybrid SC168 followed by SC Gz304, SC Sk126 and SC Sk130 were stable. However SC Sk126, SC Sk130 and SC168 were stable and had the highest grain yield.

Small values of superiority index (P_i), indicate stability according to Lin and Binns (1988). Hence the hybrid SC Sk126 followed by SC168 and SC Sk130 were stable, also these hybrids had the highest grain yield. Elto and Hallauer (1980) stated that the selection of hybrids for mean yield across environments should be emphasized first and then the relative stability of the elite hybrids across environments should be determined. Rao *et al* (2010), Fasahat *et al* (2015) and Mosa *et al* (2021) reported that corn hybrids that combine both high grain yield and stability performance are favorable. From the above results, the two promising hybrids SC Sk126 and SC Sk130 can be recommended as the best hybrids with regard to both high grain yield and stability. So this study recommended these two hybrids to be released as new commercial hybrids in Egypt.

Table 5. Mean and stability parameters values of five hybrids for grain yield.

Hybrid	Mean (ard/fed)	b_i	S^2d_i	R^2	W_i^2	P_i
SC Sk-126	33.06	1.08	1.57	0.94	30.35	1.06
SC Sk-130	32.03	1.04	1.90	0.91	31.98	5.57
SC Gz-304	31.06	0.83*	0.49	0.92	26.39	8.82
SC 162	31.96	0.98	4.85**	0.83	57.85	7.81
SC 168	32.71	1.05	1.21	0.93	25.79	3.70
Mean ($\bar{X}$)	32.16	1.00	2.01	0.90	34.47	5.59

DUS test

The morphological characteristics of the promising hybrids SC Sk126 and SC Sk130 according to the International Union for the Protection of New Varieties of Plants (UPOV) are presented in Table 6. The two hybrids were successful in the distinction, uniformity and stability (DUS) test, which is estimated by the Central Administration of Seed Certification (CASC). The most important characteristics for SC Sk126, were as follows: anthocyanin coloration of sheath of the first leaf was weak, leaf angle between blade and stem was small, time of anthesis and silking emergence was medium, plant length was very long, width of blade was medium, ear length was long, ear diameter was large, number of rows of grain was high, type of grain was intermediate, color of top of grain was yellow orange, color of dorsal side of grain was orange and coloration of glumes of cob was medium. Meanwhile, for SC Sk130, the characteristics were as follows: anthocyanin coloration of sheath of the first leaf was very strong, leaf angle between blade and stem was medium, time of anthesis and silk emergence was medium, plant length was long, width of blade was medium, ear length was medium, ear diameter was medium, number of rows of grain was medium, type of grain was flint like, color of top of grain was yellow orange, color of dorsal side of grain was orange and coloration of glumes of cob was medium.

Table 6. Morphological characteristics of the promising hybrids SC Sk126 and SC Sk130 according to the International Union for the Protection of New Varieties of Plant (UPOV).

Trait	Description	
	SC Sk126	**SC Sk130**
First leaf: anthocyanin coloration of sheath	**3**	**5**
First leaf: shape of apex	**5**	**5**
Foliage: intensity of green color	**2**	**2**
Leaf: undulation of margin of blade	**2**	**3**
Leaf: angle between blade and stem	**3**	**5**
Leaf: curvature of blade	**3**	**3**
Stem: degree of zig-zag	**2**	**2**
Tassel: time of anthesis	**5**	**5**
Tassel: anthocyanin coloration at base of glume	**1**	**1**
Tassel: anthocyanin coloration of glumes excluding base	**5**	**3**
Tassel: anthocyanin coloration of anthers	**5**	**5**
Tassel: angle between main axis and lateral branches	**5**	**5**
Tassel: curvature of lateral branches	**3**	**5**
Tassel: number of primary lateral branches	**5**	**5**
Ear: time of silk emergence	**5**	**5**
Ear: anthocyanin coloration of silks	**5**	**5**
Stem: anthocyanin coloration of brace roots	**5**	**5**
Tassel: density of spikelets	**3**	**5**
Leaf: anthocyanin coloration of sheath	**1**	**1**
Stem: anthocyanin coloration of internodes	**3**	**3**
Tassel: length of main axis above lowest lateral branch	**5**	**5**
Tassel: length of main axis above highest lateral branch	**7**	**5**
Tassel: length of lateral branch	**5**	**3**
Plant: hybrids length	**9**	**7**
Plant: ratio height of insertion of peduncle of upper ear to plant length	**5**	**5**
Leaf: width of blade	**5**	**5**
Peduncle: length	**3**	**3**
Ear: length	**7**	**5**
Ear: diameter	**7**	**5**
Ear: shape	**2**	**2**
Ear: number of rows of grain	**7**	**5**
Ear: type of grain	**3**	**2**
Ear: color of top of grain	**4**	**4**
Ear: color of dorsal side of grain	**5**	**5**
Ear: anthocyanin coloration of glumes of cob	**5**	**5**

Due to the success of the two hybrids in passing all the Egyptian crosses registration requirements, they were registered as new commercial hybrids after the issuance of Ministerial Resolution No.91 of 2022 year, whereby hybrid SC Sk126 was named by trade name as SC181 and the hybrid SC Sk130 by the trade name as SC182.

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تسجيل وإطلاق هجينين جديدين من الذرة الشامية الصفراء فى مصر

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تم تقييم ثلاث من الهجن الفردية المبشرة الصفراء (هجين فردى سخا ١٢٦ و هجين فردى سخا ١٣٠ وهجين فردى جيزة ٣٠٤) مع اثنين من هجن المقارنة (هجين فردى ١٦٢ وهجين فردى ١٦٨) فى ثلاث تجارب. التجربة الأولى لتقدير المحصول فى خمسة محطات بحثية (المستوى B) والتجربة الثانية لتقدير نسبة المقاومة لمرض الذبول المتأخر تحت ظروف العدوى الصناعية فى أربعة محطات بحثية (المستوى C) والتجربة الثالثة لتقدير المحصول فى حقول المزارعين فى ١١ محافظة (المستوى D). وذلك خلال الفترة من ٢٠١٨ الى ٢٠٢١. تفوق اثنين من الهجن وهما هجين فردى سخا ١٢٦ وهجين فردى سخا ١٣٠ فى المحصول والثبات كما اجتازا إختبار التمايز والتجانس والثبات (DUS) ونتيجة لإجتياز هذين الهجينين لكل الاختبارات الخاصة ببروتوكول تسجيل الهجن المصرية تم تسجيلهما كهجينين جديدين حيث تم تسمية الهجين الفردى سخا ١٢٦ باسم تجارى هجين فردى أصفر ١٨١ والهجين الفردى سخا ١٣٠ باسم تجارى هجين فردى أصفر ١٨٢.

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