RESEARCH | Egyptian Journal of Agricultural Research | Field Crops

Sakha 96: A new early maturing Egyptian bread wheat (*Triticum aestivum* L.) cultivar

Amin, I.A[1]., (S.M.A. Abdel-Dayem, M.A. Abdel-Rahman, M.A. Hassan, M.A.M.A. El-Maghraby, M.Y. Ghoneam, H.M. El-Gharabawy, A.A. Hagras, T.H. Abd El-Salam, E.A. Abd El-Hameed, M.A. Aglan, Kh.I. Gad, W.Z.E. Farahat, A.T.H. Moustafa, S.T. Eissa, M.M.M. Hamoda, M.M.M. Abdel-Salam, Kh.El. Ibraheem, M.N.A. El-Hawary, M.S.M. Mahmoud, I.S.M. Abdel-Kader, M.N.T. Abdel-Kader, E.Gh. Galal, M.A.H. Darweesh, A.G. Abd El-Rady, M.S. Salous, S.A. Mohamed, A.A. Zain El-Abdeen, M.M.M. Yasseen, M.M. Mokhtar, M.M. Zakaria, A.A.I Abdel-Sadek, G.M.M. Soliman, M.T. Shehab-Eldin, A.F.A. El-Kot, A.M. Sharshar, Y.S.I. Koubissy, Y.M. Faltaos, El.L.El. El-Masry, A.S. AbdelHameed, Y.A. El-Gohary, M.O.E. Mohamed, O.M. Elmoselhy, Z.A.A. El-Rashidy, A.M. Ramadan, S.E. Ibrahim, E.M.A. Khalefa, A.H.A. Hussen, M.A.M.A. Gad Allah, A.M.S.H. El-Fana, A.M.A. Nagy, W.M.A. Ghanem, W.A.A. El-Hag, E.F. Morgan, D.A.M. Hamza, H.H.A. El-Feky, A.R.H. Ibrahem, H.E. Ismaiel, M.A. Gouda, T.M. Shehab El Din, Mossad M. M. Abde-Aleem*, M.A.M. Abo Shereef, M.A.M. Eid, A.A. Ageez, S.R.S. Sabry, M.S.A Sharshar, E.M. Sadek, M.A. Moustafa, A.A. Hamada, S.E.A. Abdel-Majeed, A.M. Tammam, E.A.M. El-Sayd, H.A.H. Ashoush, H.S. Mahgoub, R.M.A.El. Kumber, M.B. Tawfiles, H.I. Hendawy, H.S. El-Borhamy, A. Menshawy, S.H. Abo El-Ela, N.A. Reiad, A.A. Sewalam, S.A.M. Seleem, S.M. Hammad, M.A.I. Khaled, S.M. Hassan, S.A. El-Sawi, R.A. Ramadan, G.A. Nour El-Din, F.A.M. Hefnawy, A.A.A. El-Hag, G.A. Shaaray, A.M.A. Gad-Allah, A.M. Abdel-All, A.A. Morad, M.E.E. Saleh)[1], O.A. Boulot[2], H.I. Saad El-Din[2] and A.A. Shahin[2]

Address:

[1] *Wheat Research Department, Field Crops Research Institute, Agricultural Research Center, Egypt, 12619 Giza, Egypt.*

[2] *Wheat Diseases Research Department, Plant Diseases Research Institute, Agricultural Research Center, Egypt, 12619 Giza, Egypt.*

Corresponding author: Mossad M. Abde-Aleem* email: mossad_abdelaleem@hotmail.com

Received: 11-02-2024 **; Accepted:** 23-05-2024 **; Published:** 05-06-2024 **DOI:** 10.21608/EJAR.2024.269437.1512

ABSTRACT

The new early bread wheat cultivar Sakha 96 was selected from the breeding program of Wheat Research Department, Field Crops Research Institute, Agricultural Research Center, Egypt, at Sakha Agricultural Research Station, considering earliness, high grain yield, and wheat rust resistance. The newly selected cultivar was evaluated at the national level in the preliminary, advanced, and on-farm yield trials started in 2017/2018 through 2022/2023 growing seasons. The new cultivar proved its superiority in earliness characterizations compared with other commercial cultivars during the successive evaluation stages in the study locations. Also, it had better and reasonable grain yield especially in late planting date than the other non-early commercial cultivars. This new variety also has high degrees of resistance to three wheat rusts in all successive growing locations and seasons. The new cultivar Sakha 96 has been described and registered according to the International Union for the Protection of new Varieties of Plants (UPOV). Thus, the Wheat Research Department recommends Sakha 96 as a new commercial wheat cultivar, especially for late planting if necessary.

Keywords: Wheat, Earliness characteristics, Planting date, Grain yield.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal grains worldwide. It is a staple food for most of the world's population, making it a crucial crop. In Egypt, wheat is the primary strategic crop and the leading food cereal. In 2023, Egypt produced 9.06 million tons of wheat grains (Economic Affairs Sector, 2023). However, this quantity is not enough to meet domestic consumption, and Egypt imports about 11 million tons (FAO, 2021) to bridge the gap between production and demand. The world is currently facing the challenges of climate change, particularly high temperatures, drought, and water scarcity, which significantly impact wheat crop production. Researchers are now focusing on wheat breeding programs to develop new varieties that can withstand these climate changes, while maintaining a high level of grain yield for food security. Due to climate changes, wheat crops are vulnerable, affecting their ability to adapt to the environmental conditions and ultimately impacting wheat grains yield (Liu *et al*., 2021).

Breeding new early-heading bread wheat varieties is an important strategy for obtaining varieties that are adapted to water deficits in Mediterranean conditions. The recurrent water shortages due to climate changes have led to a decrease in wheat grains yield (Mondal *et al.*, 2019; Nejad *et al*., 2022). Creating early-heading wheat varieties can help to avoid this issue by ensuring that the plants mature before drought occurs during grains filling stage. This is also beneficial in case of heat stress (Baloch *et al*., 2015; Mondal *et al*., 2016).Previous researches have shown that early wheat planting has several advantages, such as early harvest, the possibility of planting the following crops early, and increased efficiency of photosynthesis. However, the earliness of wheat planting often comes with a limited grains yield potential (Haro and Allan, 1997). However, it is considered one of the most important factors influencing the tolerance of wheat plants to environmental conditions (Pugsley, 1983).

Early wheat varieties require 5% less accumulated heat units to reach each growth stage compared to late varieties, as the growth stages of the early variety occur at a faster rate (University of Minnesota Extension, 2022). Additionally, early sowing leads to a relative decrease in average daily temperature, while late sowing leads to a relative increase in average daily temperature at the end of the season when summer begins. This means that wheat sown at the appropriate date needs longer days to reach physiological maturity compared to late-sown wheat. Furthermore, Soughi and Peyzbakhsh (2020) reported that late sowing leads to a decrease in the mean of growth degrees per day.

Early or late heading, anthesis, and/or physiological maturity in the wheat crop can affect the duration of the grains filling period as well as the grains filling rate, which have a direct impact on the final grains yield. Dias and Lidon (2009), Bogale and Tesfaye (2016), and Wu *et al*. (2018) have explained that the length of the grains filling period, from anthesis to physiological maturity, has a significant influence on the weight of wheat grains. Shorter periods can lead to a decrease in grains fill, ultimately impacting the final grains yield. They also added that stress conditions, such as high temperatures at the end of the growing season, can further decrease grains filling rate and period, resulting in lower grains yields, as seen in the rice crop (Farooq *et al.*, 2022). In a previous study, Nass and Reiser (1975) reported that the grains filling rate is the most critical factor in increasing wheat grains yield, rather than the duration of the filling period. They also found no relationship between the filling period and grains yield. On the other hand, Bogale and Tesfaye (2016) added that the grains filling rate is also correlated with grains yield. However, Menshawy (2007) stated that early bread wheat lines had a higher grains yield even under late planting dates compared to other commercial cultivars.

Under Egyptian agricultural conditions, there is a pressing need for an early wheat variety that can be planted after the late harvest of summer crops or some vegetable crops. This variety should reach physiological maturity quickly and yield a suitable amount of grains. However, the three wheat rust diseases continue to pose a significant threat to wheat production in Egypt. Yellow, leaf, and stem rusts are caused by *Pucciniastriiformis* f. sp. *tritici*, *P. triticina* f. sp. *tritici*, and *P. graminis* f. sp. *tritici*, respectively. These diseases are widespread and can greatly impact the yield and quality of susceptible wheat cultivars, especially when grown late in the season (Roelfs *et al*., 1992; Huerta-Espino *et al*., 2011; Shahin, 2020; Shahin *et al*., 2020). Therefore, it is crucial to develop wheat genotypes with high resistance to these rusts, including new races (Shahin *et al*., 2021).

The strategy and the research plan of the Wheat Research Department, the Field Crops Research Institute, Agricultural Research Center, Egypt, aims to develop new high-yielding wheat cultivars that possess high grains quality, disease resistance, and early maturity. These attributes are crucial in order to mitigate the impact of climate changes and stressors that may occur towards the end of the growing season. Additionally, the wheat cultivars should be well-suited to the environmental conditions in all wheat-growing areas in Egypt (Kumber *et al*., 2022). The main objective of breeding and releasing the new variety, Sakha 96, is to produce a bread wheat cultivar that is tolerant to climatic changes, specifically high temperatures and water deficiency towards the end of the growing season. This will help to avoid any losses in wheat grains yield. Furthermore, the new wheat cultivar should exhibit resistance to diseases, particularly the three wheat rust diseases.

MATERIALS AND METHODS

Breeding of the newly released early bread wheat variety Sakha 96 started in the growing season of 2008/2009, in the bread wheat breeding program at Sakha Agricultural Research Station, Wheat Research Department (WRD), Field Crops Research Institute (FCRI), Agricultural Research Center (ARC), Egypt, by crossing the variety (MINO), which is medium early maturing and has a good grains yield, and the line (Sakha 12/5/Kvz//Cno 67/Pj 62/2/Yd”s”/Blo”s”/4/K 134 (60)/Vee), which is remarkable early maturing line with relatively low grains yielder. The goal of this cross was to obtain a new bread wheat cultivar early in maturity with an economically suitable grains

yield, suitable for late cultivation, and tolerant to climatic condition changes that affect wheat production, especially at the end of the growing season.

The pedigree of the new early variety is MINO/6/Sakha 12/5/Kvz//Cno 67/Pj 62/2/Yd"s"/Blo"s"/4/K 134 (60)/Vee. The F1 of the hybrid was planted in the growing season of 2009/2010, and selection was practiced in the successive segregating generations in WRD in the Sakha Agricultural Research Station, starting from F2 until F6, during the growing seasons of 2010/2011 up to 2014/2015. Early maturity, disease resistance, and plant performance were taken into considerations during selection procedures. The selection history of the new variety is S. 16869-010S-07S-1S-2S-0S.

In 2015/2016 growing season, the new variety was planted in an observation nursery with other selected early maturing lines to confirm its early maturing trait and its performance. In the growing season of 2016/2017, it was planted in Sakha Early Maturing Yield Trial (SEMYT), in Sakha Agricultural Research Station, compared with the early maturing variety "Sids 4" and the commercial cultivar "Misr 2". Starting from the growing season of 2017/2018, Sakha 96 was tested on the national level, through 2019/2020 growing season under various environmental conditions. In 2017/2018 growing season, Sakha 96 was tested in the preliminary yield trial for early maturing bread wheat lines (AEMBW), compared with the two commercial relatively early maturing cultivars "Gemmieza 11 and Sids 12" and the earliest variety "Sids 4". The trial was planted in four agricultural research stations, i.e. Sakha, Gemmieza, Sids, and Shandaweel, ARC, Egypt. In the two successive growing seasons of 2018/2019 and 2019/2020, the new cultivar Sakha 96 came to the final level of testes and it was tested in the advanced yield trial for early maturing bread wheat genotypes (DEMBW). In 2018/2019 growing season, it was compared with the two high yielding cultivars "Shandaweel 1 and Misr 2" in addition to the early cultivar "Sids 4", while in 2019/2020 growing season, it was compared with the two early maturing varieties "Sakha 1001 and Sids 4". The trial was planted on two planting dates, the recommended planting date and one month later. The trial was also planted in the above mentioned agricultural research stations.

In 2022/2023 growing season, the new cultivar was planted in the On-Farm trial (OF) with four high yielding commercial cultivars "Giza 171, Misr 3, Misr 4, and Sakha 95" in large scale plots (10 m X 25 m = 250 m^2) to demonstrate the performance, earliness, wheat rusts resistance, and grains yield of the new cultivar. The OF trial was planted in five locations in Sakha, Gemmieza, Nubaria, Sids, and Shandaweel (This experiment was not grown in replicates and was not statistically analyzed). All A, D, and OF trials were drilled using seeding rate of 50 kg seeds $faddan^{-1}$. The experimental plot area was 4.2 m^2 (6 rows X 3.5 m long X 20 cm apart) in the A trial and 12.6 m^2 in the D trial (18 rows X 3.5 m long X 20 cm apart), using Randomized Complete Blok Design (RCBD) with four replications. All the recommended cultural practices for each zone were applied, except the second planting date in the D trial. During the life cycle, heading and maturity dates were recorded.

Before harvest, number of spikes in three internal rows by 0.05 m long were calculated and converted to number of spikes per square meter (NS). At harvest time, all the area of each experimental plot was harvested and threshed. Grains yield was weighed and adjusted to ardab $faddan^{-1}$ (GY). All the data were subjected to the statistical analysis according to Steel and Torrie, (1980). Comparison between means was done using the Least Significant Difference (LSD), at 5% level of probability, according to Waller and Duncan (1969). Also, stability parameters for grains yield and days to maturity of the advanced yield trials over the two seeding dates were calculated according to Eberhart and Russell (1966). Disease severity (%) was estimated for the new cultivar Sakha 96 in the three growing seasons of 2017/2018 up to 2019/2020 under natural conditions. Disease severity was reported in six locations (Sakha, Gemmieza, Nubaria, Itay El-Baroud, Kafr El-Hamam, and Sids Agricultural Research Stations) as a naturally hot spots of the three wheat rusts based on the percentage of leaf area covered with rust pustules. Field reaction of the three rusts infection types was classified into five categories, highly resistant (0), resistant (R), moderately resistant (MR), moderately susceptible (MS), and susceptible (S) according to Stakman *et al.* (1962). The DUS (Distinguish, Uniformity, and Stability) test was done according to UPOV (the International Union for the Protection of New Varieties of Plants) by the Central Administration of Seed Certification (CASC), Egypt.

RESULTS

Preliminary yield trial (A BWE):

Data in Table 1 show that the earliness characteristics of a new cultivar, Sakha 96, in comparison to two commercial cultivars; Gemmieza 11 and Sids 12. The study was conducted in four different locations; Sakha, Gemmieza, Sids, and Shandaweel. The data shows that Sakha 96 was the earliest in terms of days to heading and

days to physiological maturity in Sakha location only. In the locations of Gemmieza, Sids, and Shandaweel, the check cultivar "Sids 4" was the earliest, followed by Sakha 96, with significant ($P < 0.05$) differences from the other two cultivars. When taking data from all locations into account, Sakha 96 had an average of 73.8 days from sowing to heading and 131.9 days to physiological maturity, while the overall averages for all cultivars were 80.1 days and 153.6 days, respectively. While Sakha 96 was distinguished by its earliness in heading and physiological maturity, it also had the longest grains filling period compared to “Sids 4” and the other two commercial cultivars. This was evident in data from all locations, with Sakha 96 recording 58.2 days on average, while the other cultivars had periods of 57.3, 52.3, and 54.3 days for “Sids 4, Gemmieza 11, and Sids 12”, respectively. In summary, Sakha 96 stands out for its earliness in heading and physiological maturity, but also for its longer grains filling period compared to the other tested cultivars. This makes it a promising new cultivar, particularly for the Sakha location.

Table 1. Earliness and grain yield (ardab faddan^{-1}) of wheat cultivars in the preliminary yield trial (A B.W. Early) in 2017/2018 growing season.

Cultivars	DH	DM	GFP	GY	GFR
Sakha					
Sakha 96	71.5	125.5	54.0	20.25	13.5
Sids 4	75.8	127.0	51.3	17.04	11.9
Gemmieza 11	85.8	136.0	50.3	19.94	14.3
Sids 12	86.8	140.8	54.0	18.20	12.1
Mean	80.0	132.3	52.4	18.86	13.0
LSD 5%	3.0	2.8	3.1	2.8	1.7
Gemmieza					
Sakha 96	73.3	138.8	65.5	18.22	10.0
Sids 4	71.3	134.5	63.3	13.92	7.9
Gemmieza 11	84.8	141.5	56.8	23.43	14.9
Sids 12	84.5	147.8	63.3	20.32	11.6
Mean	78.5	140.7	62.2	19.0	11.1
LSD 5%	3.0	2.7	2.9	2.8	1.9
Sids					
Sakha 96	76.5	137.8	61.3	18.55	10.9
Sids 4	76.0	134.0	58.0	14.92	9.3
Gemmieza 11	93.3	143.0	49.8	23.06	16.7
Sids 12	95.5	144.5	49.0	19.58	13.2
Mean	85.3	139.8	54.5	19.58	13.2
LSD 5%	1.8	4.4	4.4	1.4	1.5
Shandaweel					
Sakha 96	73.8	125.8	52.0	15.21	10.5
Sids 4	67.0	123.3	56.3	13.13	8.4
Gemmieza 11	82.5	134.8	52.3	18.05	12.4
Sids 12	83.8	134.5	50.8	18.51	13.1
Mean	76.8	129.6	52.9	16.22	11.1
LSD 5%	8.6	4.9	5.9	5.2	4.0
Over all					
Sakha 96	73.8	131.9	58.2	18.06	11.2
Sids 4	72.5	129.7	57.2	14.75	9.3
Gemmieza 11	86.6	138.8	52.3	21.12	14.5
Sids 12	87.6	141.9	54.3	19.70	13.1
Mean	80.1	135.6	55.5	18.41	12.0
LSD 5%	2.0	1.6	1.9	1.4	1.1

DH: Days to heading, DM: Days to maturity, GFP: Grain filling period, (day) GFR: Grain filling rate (g/day/m^2).

The results in Table 1 show that the two commercial cultivars, Gemmieza 11 and Sids 12, outperformed the local cultivars, Sakha 96 and Sids 4, in all three locations (Gemmieza, Sids, and Shandaweel locations). Gemmieza 11 and Sids 12 had a higher average grain yield of 21.12 and 19.7 ardab faddan^{-1}, respectively, while Sakha 96 produced an average of 18.06 ardab faddan^{-1}. However, in Sakha location, Sakha 96 showed promising results, with a yield of 20.25 ardab faddan^{-1}, which was significantly higher ($P < 0.05$) than Sids 4. It is worth noting that Gemmieza 11 and Sids 12 not only had the highest grain yield but also had the highest grains filling rate, with an average of 14.5 and 13.1 g/day/m^2, respectively. On the other hand, Sids 4, the early check cultivar, had the lowest grains yield and grains filling rate, with an average of 9.3 g/day/m2.

Advanced yield trial (D BWE):
The results in Table 2 show that the new cultivar Sakha 96, as an early cultivar, developed to the heading stage after an average of 87.8 days from sowing when planted at the recommended date and after an average of 94.3 days when planted one month later. It was earlier than the other tested cultivars, even the very early one "Sids 4". It was the earliest one in Sakha and Gemmieza locations at the two seeding dates, and Sids location at the first seeding date. However, at the second seeding date in Sids location, and both seeding dates in Shandaweel location, the cultivar "Sids 4" was earlier than Sakha 96 with no significant ($P > 0.05$) difference. The data in Table 2 show that the wheat cultivar Sakha 96 was the earliest one to reach the physiological maturity stage in Sakha, Gemmieza, and Sids locations. However, in Shandaweel location, both Sids 4 and Shandaweel 1 cultivars were earlier than Sakha 96. Generally, the cultivar Sakha 96 reached the physiological maturity stage after 136.3 or 129.0 days from planting when it was planted at the recommended time and one month later, respectively. On the other hand, the earliest cultivar "Sids 4" reached the physiological maturity stage after 135.1 days or 127.7 days from planting in the respective seeding dates. Overall, the tested commercial wheat cultivars "Shandaweel 1 and Misr 2" were the most delayed in reaching the physiological maturity stage.

Table 2. Earliness and grain yield (ardab faddan^{-1}) of the advanced yield trial (D B.W. Early) in 2018/2019 growing season.

Cultivars	DH		DM		NS		GY	
	SD1	SD2	SD1	SD2	SD1	SD2	SD1	SD2
Sakha								
Sakha 96	81.0	86.5	144.5	136.5	546.5	433.0	23.4	17.08
Shandaweel 1	98.5	94.0	154.0	141.8	403.0	369.0	13.36	11.51
Misr 2	105.8	96.8	156.5	141.5	555..0	382.5	13.54	8.88
Sids 4	83.0	88.0	141.0	133.8	365.0	237.0	8.16	2.13
Mean	92.1	91.3	149.0	138.4	467.4	355.4	14.62	9.90
Gemmieza								
Sakha 96	74.8	89.3	137.0	132.3	486.0	418.0	19.58	19.58
Shandaweel 1	98.3	99.8	161.0	143.3	455.5	389.0	17.80	17.80
Misr 2	105.3	100.3	165.0	144.3	480.5	388.0	18.15	18.15
Sids 4	78.5	92.3	140.5	133.5	296.0	298.0	16.22	13.55
Mean	89.2	95.4	150.9	138.3	429.5	373.3	17.27	17.27
Sids								
Sakha 96	81.0	89.0	149.0	134.8	520.0	510.0	14.54	12.49
Shandaweel 1	102.8	104.3	162.5	143.8	575.0	574.0	29.08	12.49
Misr 2	102.8	104.8	158.8	143.5	565.0	500.0	28.95	15.07
Sids 4	85.3	87.3	145.8	134.3	495.0	480.0	12.55	9.93
Mean	92.9	96.3	154.0	139.1	538.8	516.0	21.28	13.68
Shandaweel								
Sakha 96	114.5	112.5	114.5	112.5	390.0	351.8	17.20	22.26
Shandaweel 1	109.5	107.5	109.5	107.3	398.3	284.0	12.49	18.86
Misr 2	116.5	112.5	119.0	113.8	418.3	328.0	15.07	19.60
Sids 4	113.3	111.3	113.3	109.3	400.0	311.3	9.98	17.94
Mean	113.4	110.9	134.1	110.7	401.6	318.8	13.68	19.67
Over all locations								
Sakha 96	87.8	94.3	136.3	129.0	485.6	428.2	18.68	19.03
Shandaweel 1	102.3	101.4	146.8	134.0	457.9	404.0	18.19	15.17
Misr 2	107.6	103.6	149.8	135.8	504.7	399.6	18.93	15.42
Sids 4	90.0	94.7	135.1	127.7	389.0	331.6	11.06	10.89
Mean	96.9	98.5	142.0	131.6	459.3	390.8	16.71	15.13
LSD 5%	1.6	2.1	1.7	1.0	22.6	40.2	0.58	0.42

DH: Days to heading, DM: Days to maturity, NS: Number of spike m$^{2\ -1}$, GY: Grain yield, ardab faddan^{-1}.

Regarding the number of spikes per square meter, it was noted from the results in Table 2 that the wheat cultivar "Sakha 96", when planted at the recommended seeding date, did not produce the highest number of spikes per square meter, except at the Gemmieza location. However, when it was planted at the late date, it produced the largest number of spikes per square meter in Sakha, Gemmieza, and Shandaweel locations, with respective numbers of 433.0, 418.0, and 315.8 spikes/m^2, respectively. At the Sids location, it was ranked second after the cultivar "Shindaweel 1", producing 510.0 spikes/m^2. Therefore, the new cultivar "Sakha 96", when planted late, demonstrated its superiority in producing higher grains yields of 17.08, 19.58, and 22.26 ardab faddan^{-1} in the same respective locations where it produced the largest number of spikes per square meter. Furthermore, it should be noted that the number of spikes per square meter for the three tested varieties was affected by the planting date and significantly ($P < 0.05$) decreased at the late planting date. This decrease had an overall average of 13.7, 17.4,

and 16.6% for "Sakha 96", "Sakha 1001", and "Sids 4", respectively. Overall, at the tested locations, the new cultivar "Sakha 96" demonstrated its superiority in producing the largest number of spikes (428.2 spikes/m^2) and the highest grain yield (19.03 ardab faddan^{-1}) compared to the other tested cultivars, with significant ($P < 0.05$) differences.

In the 2019/2020 growing season, the new cultivar “Sakha 96” was compared to two early cultivars “Sakha 1001” and “Sids 4”. The results in Table 3 show that when planting took place at the recommended date, Sakha 96 was not the earliest in heading date. However, it was the earliest in Sakha and Shandaweel locations, with its heading occurring after 78.8 and 78.0 days of planting, respectively. On the other hand, Sids 4 was the earliest in Gemmieza and Sids locations, with heading occurring after 79.0 and 79.5 days of planting, respectively. When considering the earliness in reaching physiological maturity, Sids 4 was consistently the earliest in all locations (Table 3), regardless of whether it was planted at the recommended or late date. Sids 4 reached physiological maturity after an average of 136.0 or 134.4 days, depending on the planting date. The new cultivar “Sakha 96” ranked second in reaching physiological maturity after Sids 4 in both Sakha and Shandaweel locations, with average times of 139.8 and 136.7 days, respectively. In Gemmieza, it was ranked as the third and last, reaching maturity after an average of 141.3 and 137.0 days for the recommended and late planting dates, respectively. At the Sids site, it ranked second when planted at the recommended date (138.8 days after planting) and third when planted late (147.8 days after planting).

Table 3. Earliness and grain yield (ardab faddan^{-1}) of the advanced yield trial (D B.W. Early) in 2019/2020 growing season**.**

Cultivars	DH		DM		NS		GY	
	SD1	SD2	SD1	SD2	SD1	SD2	SD1	SD2
Sakha								
Sakha 96	78.8	81.3	142.8	134.0	355.5	198.5	22.02	10.20
Sakha 1001	82.8	86.3	143.0	137.3	421.0	281.5	21.37	11.04
Sids 4	79.8	85.0	138.5	132.0	117.5	35.0	7.47	2.43
Mean	80.4	84.2	141.4	134.4	298.0	171.7	16.95	7.89
Gemmieza								
Sakha 96	79.3	71.5	141.3	137.0	357.5	343.0	24.39	22.06
Sakha 1001	80.0	74.8	137.8	132.3	363.8	347.3	25.30	17.94
Sids 4	79.0	71.3	134.0	131.3	351.3	334.8	16.51	8.43
Mean	79.4	72.5	137.7	133.5	357.5	341.7	22.07	16.15
Sids								
Sakha 96	79.8	97.8	138.8	147.8	362.5	338.5	14.15	23.15
Sakha 1001	84.0	104.0	138.5	149.8	382.5	371.0	22.15	21.22
Sids 4	79.5	99.8	137.5	146.5	337.5	295.0	17.12	16.11
Mean	81.1	100.5	138.3	148.0	360.8	334.8	18.05	20.16
Shandaweel								
Sakha 96	78.0	68.0	136.3	128.0	318.5	273.8	15.27	11.73
Sakha 1001	85.0	74.3	139.5	133.3	332.3	254.3	12.73	11.20
Sids 4	82.8	74.0	134.0	127.8	301.8	248.8	13.20	10.61
Mean	81.9	72.1	136.6	129.7	317.5	258.9	13.34	11.19
M Over all locations								
Sakha 96	78.9	79.6	139.8	136.7	348.5	288.4	19.96	16.79
Sakha 1001	82.9	84.8	139.7	138.1	374.9	313.5	20.57	15.35
Sids 4	80.3	82.5	136.0	134.4	277.0	228.4	13.58	9.40
Mean	80.7	82.3	138.5	136.4	333.5	276.8	17.70	13.84
LSD 5%	1.2	1.0	1.1	1.5	15.7	29.1	0.43	0.31

DH: Days to heading, DM: Days to maturity, NS: Number of spike $m^{2\ -1}$, GY: Grain yield, ardab faddan^{-1}.

The results in Table 3 also show that the cultivar “Sakha 1001” produced the largest number of spikes/m^2, whether planted at the recommended date or at the late date. It outperformed the other two cultivars in all test locations, with respective average numbers of spikes of 374.9 and 313.5 spikes/m^2. The new cultivar “Sakha 96” ranked second with average numbers of 348.5 and 288.4 spikes/m^2. The cultivar “Sids 4”, classified as sparsely tillering, came in third place with average numbers of 277.0 and 228.0 spikes/m^2. In terms of grains yield (Table 3), when planted at the recommended date, Sakha 96 did not perform as well and was not the best in all locations. However, it was the best in Sakha and Shandaweel locations, with respective grains yields of 22.02 and 15.27 ardab faddan^{-1}, respectively. It ranked second in Gemmieza and third in Sids, with grains yields of 24.39 and 14.15 ardab faddan^{-1},

respectively. On average, Sakha 96 produced 19.96 ardab faddan-1, second only to Sakha 1001, which produced 20.57 ardab faddan^{-1}. In terms of late planting, Sakha 96 demonstrated its superiority over the other two cultivars, producing the highest grains yield in all test locations with 10.20, 22.06, 23.15, and 11.73 ardab faddan^{-1} in Sakha, Gemmieza, Sids, and Shandaweel, respectively. On average, it yielded 16.79 ardab faddan^{-1}, with significant (P < 0.05) differences when compared to the other two cultivars.

On-farm yield trial (OF BWE):

When the on-farm trial was conducted in the 2022/2023 growing season to compare the new cultivar "Sakha 96" with the commercial cultivars commonly used by wheat farmers, the results in Table 4 show the superiority of Sakha 96 in earliness characteristics in all experimental locations. This was consistent whether this cultivar was planted at the recommended date or one month later. In both cases, Sakha 96 reached the heading stage after an average of 67.8 or 68.8 days from planting. Additionally, Sakha 96 was early in reaching physiological maturity in all locations, taking 136.4 or 120.4 days, respectively. When compared to other cultivars, Sakha 96 reached maturity 10.9 - 12.7 days earlier at the recommended planting date and 6.3 - 8.0 days earlier when planted late. In terms of grains yield, the results in Table 4 show that most of the cultivars outperformed Sakha 96. This was true in both seeding dates, with an average yield of 22.06 and 19.19 ardab faddan^{-1}. However, all cultivars experienced a decrease in yield when planted late. On average, Sakha 96's yield decreased by 13%, while the remaining cultivars showed a decrease ranging from 23.1 - 25.1%. Overall, the data suggests that Sakha 96 is an early-maturing cultivar, but it may not be the most productive in terms of grains yield.

Table 4. Earliness and grain yield (ardab faddan^{-1}) of the On-farm yield trial (OF B.W. Early) in 2022/2023 growing season.

Cultivars	DH		DM		GY	
	SD1	SD2	SD1	SD2	SD1	SD2
Sakha						
Sakha 96	65.3	71.5	139.3	119.0	19.76	21.58
Giza 171	85.8	85.0	145.8	128.8	26.22	17.96
Misr 3	89.5	85.5	146.8	129.0	30.03	23.93
Misr 4	90.8	86.3	148.5	130.5	26.06	18.79
Sakha 95	96.3	86.8	149.0	126.8	23.16	20.38
Mean	85.5	83.0	145.9	126.8	25.046	20.53
Gemmieza						
Sakha 96	66.0	64.3	130.5	114.0	20.91	11.91
Giza 171	84.3	84.5	148.5	120.5	22.43	12.21
Misr 3	87.5	84.5	153.3	124.5	26.66	15.98
Misr 4	89.8	85.5	153.5	128.0	16.88	16.12
Sakha 95	90.3	86.8	154.5	129.0	27.02	16.67
Mean	83.6	81.1	148.1	123.2	22.78	14.58
Nubaria						
Sakha 96	67.3	61.0	136.3	125.5	14.18	12.11
Giza 171	92.8	82.0	146.0	130.5	15.00	12.38
Misr 3	92.0	81.5	143.3	130.8	17.45	15.63
Misr 4	94.0	82.0	144.5	131.0	17.89	14.72
Sakha 95	95.3	88.0	144.5	128.0	16.52	16.02
Mean	88.3	78.9	142.9	129.2	16.21	14.17
Sids						
Sakha 96	70.8	75.0	142.8	124.0	28.85	29.65
Giza 171	91.8	89.0	149.8	130.0	33.34	27.0
Misr 3	93.5	89.5	148.5	129.3	35.17	29.20
Misr 4	93.3	91.8	150.5	130.5	37.55	30.29
Sakha 95	96.5	89.5	149.8	130.3	34.05	27.32
Mean	89.2	87.0	148.3	128.82	33.79	28.69
Shandaweel						
Sakha 96	69.3	72.0	130.5	113.0	26.58	20.68
Giza 171	90.5	87.0	146.0	123.0	35.32	18.53

Table 4 Continued						
Misr 3	96.0	87.0	151.5	121.8	32.95	21.83
Misr 4	96.8	89.3	151.8	123.5	31.31	17.23
Sakha 95	99.5	88.5	151.5	121.3	28.84	19.30
Mean	90.4	84.8	146.3	120.5	31.00	19.51
Over all locations						
Sakha 96	67.7	68.8	136.4	120.4	22.06	19.19
Giza 171	89.0	85.5	147.3	127.5	26.46	17.62
Misr 3	91.7	85.6	148.0	127.3	28.45	21.31
Misr 4	92.9	87.9	149.1	128.4	25.94	19.43
Sakha 95	95.6	87.9	148.9	126.7	25.92	19.94
Mean	87.4	83.0	145.9	126.1	25.7/	19.49

DH: Days to heading, DM: Days to maturity, NS: Number of spike $m^{2\ -1}$, GY: Grain yield, ardab faddan^{-1}, SD1: Firat seeding date and SD2: Later seeding date.
This experiment was not grown in replicates and was not statistically analyzed

Stability parameters:
Grains yield stability parameters for grain yield and days to maturity were calculated for the two advanced yield trials during the 2018/2019 and 2019/2020 wheat growing seasons, across two seeding dates. The parameters were based on the method outlined by Eberhart and Russell (1966). A stable cultivar is one that consistently performs well across different environments, with a regression coefficient of one and no deviation from the regression mean square. Results in Tables 5 and 6 show that the new bread wheat cultivar, Sakha 96, demonstrated better stability parameters than the tested commercial cultivars at all experimental locations during the two growing seasons.

Table 5. Grains yield and days to maturity stability for Sakha 96 with the bread wheat commercial cultivars in 2018/2019 growing season (in the advanced yield trial, over the two seeding dates).

Cultivars	**Grain yield**		**Days to maturity**	
	bv	**S^2d**	**b**	**S^2d**
Sakha 96	1.239	0.121	1.016	-0.676
Shandaweel 1	1.076	0.315	1.025	16.568
Misr 2	0.671	0.182	0.974	-0.447
Sids 4	0.878	1.047	1.019	-0.302

bv: Regression coefficient and S^2d: Standard division

Table 6. Grains yield and days to maturity stability for Sakha 96 with the bread wheat commercial cultivars in 2019/2020 growing season (in the advanced yield trial, over the two seeding dates).

Cultivar	**Grain yield**		**Days to maturity**	
	bv	**S^2d**	**b**	**S^2d**
Sakha 96	1.023	-0.112	1.003	1.545
Sakha 1001	1.319	-2.737	1.045	1.872
Sids 4	1.061	-0.604	0.931	0.774

bv: Regression coefficient and S^2d: Standard division

Resistance to the three wheat rusts:
The newly developed early wheat cultivar "Sakha 96" was evaluated for its resistance to the three wheat rusts at the adult stage under natural conditions in six locations during three consecutive growing seasons: 2017/2018 in the preliminary yield trial for early maturing bread wheat lines (Table 7), 2018/2019, and 2019/2020 in the advanced yield trial for early maturing bread wheat genotypes (Tables 6 and 7). The rust reaction data from the preliminary yield trial showed that the "Sakha 96" cultivar exhibited very high resistance to the three wheat rusts, except in the Nubaria and Etay El-Baroud locations. It was classified as "TrS," indicating very high resistance, only

for leaf rust, while the other check cultivars were susceptible or showed other types of resistance to the three wheat rusts in all locations.

Table 7. Rust severity of Sakha 96 wheat cultivar to yellow, leaf and stem rusts compared to the check cultivars in 2017/2018 growing season.

Locations	Cultivars	Wheat rusts		
		Yellow rust	Leaf rust	Stem rust
Sakha	Sakha 96	0	0	0
	Sids 4	0	0	40S
	Gemmieza 11	10R	10R	5MR
	Sids 12	0	0	0
Gemmieza	Sakha 96	0	0	0
	Sids 4	10S	10S	0
	Gemmieza 11	0	0	60S
	Sids 12	10S	10S	0
Nubaria	Sakha 96	0	TrS	0
	Sids 4	5S	5S	20S
	Gemmieza 11	5S	10S	30S
	Sids 12	0	0	5S
Etay El-Baroud	Sakha 96	0	TrS	0
	Sids 4	5S	5S	20S
	Gemmieza 11	TrS	5S	50S
	Sids 12	0	0	5S
Kafr El-Hamam	Sakha 96	0	0	0
	Sids 4	50S	30S	0
	Gemmieza 11	10S	10S	40S
	Sids 12	20S	20S	10S
Sids	Sakha 96	0	0	0
	Sids 4	0	0	40S
	Gemmieza 11	10R	10R	5MR
	Sids 12	0	0	0

0: Highly resistant, R: Resistant, MR: Moderately resistant, MS: Moderately susceptible and S: Susceptible.
Numbers: Disease severity (%)

For the two consecutive growing seasons of 2018/2019 and 2019/2020, in the advanced yield trial (D), the new cultivar “Sakha 96” showed good resistance to the three wheat rusts compared to the check cultivars (Tables 7 and 8). The results showed that Sakha 96 was highly resistant to the three rusts in all the test locations except in Kafr Al-Hamam, where it was moderately resistance to each of yellow rust and leaf rust, and it was moderately susceptible to stem rust. The check cultivars were susceptible with different degrees by the three rusts.

Table 7. Rust severity of Sakha 96 wheat cultivar to yellow, leaf and stem rusts compared to the check cultivars in 2018/2019 growing season.

Locations	Cultivars	Wheat rusts		
		Yellow rust	Leaf rust	Stem rust
Sakha	Sakha 96	0	0	0
	No. 6	70S	0	50S
	No. 7	80S	0	0
Gemmeiza	Sakha 96	0	0	0
	No. 6	0	0	0
	No. 7	0	0	0
Nubaria	Sakha 96	0	0	0
	No. 6	20S	40S	0
	No. 7	0	0	0
Itay El-Baroud	Sakha 96	0	0	0
	No. 6	10S	30S	0

	Table 7 Continued			
	No. 7	0	0	0
Kafr El-Hamam	Sakha 96	10MR	5MR	5MS
	No. 6	30MS	50S	0
	No. 7	5MS	5MR	10S
Sids	Sakha 96	0	0	0
	No. 6	70S	0	50S
	No. 7	80S	0	0

Table 8. Rust severity of Sakha 96 wheat cultivar to yellow, leaf and stem rusts compared to the check cultivars in 2019/2020 growing season.

Locations	**Cultivars**	**Wheat rusts**		
		Yellow rust	**Leaf rust**	**Stem rust**
Sakha	Sakha 96	10MR	0	0
	No. 4	20MS	0	0
	No. 5	70S	0	0
Gemmeiza	Sakha 96	5MR	0	0
	No. 4	20S	0	0
	No. 5	60S	0	0
Nubaria	Sakha 96	0	TrMR	0
	No. 4	5MS	0	0
	No. 5	60S	0	0
Itay El-Baroud	Sakha 96	0	0	0
	No. 4	5MS	0	0
	No. 5	50S	0	0
Kafr El-Hamam	Sakha 96	10MR	0	0
	No. 4	10MS	0	0
	No. 5	70S	0	30S
Sids	Sakha 96	0	0	0
	No. 4	0	0	0
	No. 5	50S	0	0

Distinguish, Uniformity and Stability (DUS) test:

The DUS test for the new cultivar "Sakha 96" was determined by the Central Administration of Seed Certification (CASC) for two successive seasons according to the International Union for the Protection of new Varieties of plants (UPOV). This test had been done before the registration and releasing the new cultivar. Table 9 shows the morphological characterizations of the new bread wheat cultivar "Sakha 96" according to the UPOV regulations.

Table 9. Morphological characterization of the newly released bread wheat cultivar "Sakha 96".

Characterization	**Description**
Pigmentation of coleoptiles	**(1)**
Growth habit	(1)
Anthocyanin coloration of flag leaf auricle	(3)
Flag leaf rolling	(5)
Number of days to 50% heading	(5)
Glaucosity of flag leaf sheath	(7)
Glaucosity of the spike	(7)
Glaucosity of ear neck	(5)
Plant height	(7)
Thickness of parenchyma wall	(3)
Spike shape	(1)
Density of ear	(3)
Spike length excluding awns	(5)
Presence of awns	(3)
Awns length	(3)

Table 9 Continued	
Spike color at maturity	(1)
Hair density at the lower edge of the rachis	(3)
Width of lower glume	(3)
Sheulder shape of glume	(9)
Length of glume beak	(3)
Shape of glume beak	(3)
Hair density in the lower glume	(3)
Shape of lemma beak	(3)
Grain color	(1)
Seasonal type	(1)

DISCUSSION

In general, the absolute precocity of the Sakha 96 cultivar is evident in its earliness, whether in terms of days to heading or days to physiological maturity. Additionally, it has shown a higher grain yield in Sakha conditions. This is likely due to the selection process during the successive segregated populations where the main objective was to obtain a wheat genotype with earliness, high yield, and resistance to rust diseases. Taking into consideration that the selection took place in the same location, it is possible that the cultivar is specifically adapted to this location. The Sakha 96 cultivar was selected to be early in terms of heading time, but it was not the earliest to reach physiological maturity. This suggests that it has a relatively longer grains filling period, resulting in a higher grain yield compared to the early cultivar "Sids 4". This gives it the advantage of being an early cultivar with an economical grains yield.

The grains filling period of the new wheat cultivar "Sakha 96" is significantly ($P < 0.05$) longer compared to other existing cultivars. This can be attributed to its early heading, rather than its physiological maturity. Although the grains filling period positively correlates with grain yield, studies show that its duration is not a major limiting factor. In addition, there seems to be a direct relationship between grains filling rate and grain yield, with varieties that have a higher grains filling rate achieving higher yields compared to those with a lower filling rate. These findings are consistent with previous studies conducted by Dias and Lidon (2009), Nonpara (2011), Bogale and Tesfaye (2016), and Wu et al. (2018). Similarly, Nass and Reiser (1975) reported that a higher grains filling rate is more crucial in increasing grain yield compared to a longer filling period. Therefore, planting the new cultivar "Sakha 96" can lead to obtaining a higher yield. Interestingly, the data obtained also suggest that the number of days from planting to heading of "Sakha 96" remains consistent, whether it is planted on the recommended date or one month later. This indicates that the heading date of the cultivar may not be significantly affected by a delay in planting. Therefore, if a farmer is forced to plant late, they can still expect to harvest at the proper time by choosing this cultivar.

The wheat variety "Sakha 96" was the least affected by the delay in the planting date. When it was planted a full month later than the recommended date, the number of ears per square meter only decreased by 13.7%, which is the lowest percentage compared to other varieties. This demonstrates the possibility of successfully cultivating Sakha 96 even with a late planting date. The superiority of this new cultivar in producing a larger number of spikes per square meter and higher grain yield, even when planted late, confirms its reliability in producing an appropriate economic yield. The low grains yield of the early check cultivar "Sids 4" and the new cultivar "Sakha 96", which is earlier than the commercial cultivars, may be due to the negative correlation between earliness and yield in wheat. This is because of the shorter vegetative stage, which can result in decreased plant production (Shavrukov et al., 2017).

From Table 4, we can see that there is a clear decrease in grain yield when wheat is planted at a later date. However, the decrease is lowest for the "Sakha 96" wheat cultivar, indicating that it is a better option for farmers who are forced to plant late. Furthermore, Menshawy (2007) suggests that early bread wheat lines have a higher yield potential than non-early commercial cultivars when planted late. This is supported by the stability results of this study, which show that "Sakha 96" has a consistent and stable grains yield and matures early under both planting dates in two growing seasons. The wheat cultivar "Sakha 96" is a new early wheat cultivar that has shown high resistance to the three wheat rust diseases in three growing seasons under natural conditions. This new

cultivar was carefully selected at Sakha Agricultural Research Station, which is known for its high prevalence of rust diseases. The selection process aimed to choose genetically resistant plants to the three rust diseases, resulting in the development of the wheat cultivar "Sakha 96".

CONCLUSION

Earliness, especially in physiological maturity with having an economic grains yield, leads to save irrigation water due to the shorter period of vegetative growth and the shorter duration of the crop cycle in the field. It also leads to early crop harvesting and gives an opportunity to plant the next crop early. This achieves the goal of breeding and developing early wheat cultivars. Sakha 96 bread wheat cultivar is recommended for late planting after harvesting late summer crops as potatoes and other vegetable crops, especially in Middle Egypt region (Bani-Suef and El-Menia Governorates).

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سخا 96: صنف قمح خبز مصري جديد مبكر النضج

إبراهيم عبدالهادي أمين[1]، صبحي محمد علي عبدالدايم ،ماجدة السيد عبدالرحمن، منال عبدالصمد حسن ،ماهرعبدالمنعم محمد علب المغربي، محمد يوسف غنيم مبار ك، هدى مصطفى الغرباوي ،عادل عبدالعزيز هجرس، ثناء حمد عبدالسلام، السيد علي محمد عبدالحميد، مؤمن عبدالوهاب عجلان، خالد إبراهيم محمد جاد، وليد زكي اليماني فرحات، أحمد طه حسن مصطفى، شريف ثابت عيسى، محمد مرعي محمد حمودة، محمد محي محمد عبدالسلام، خالدالدمرداش إبراهيم، محمد نبيل عوض الهواري، محمود شمروخ محمد محمود، إبراهيم صبري محمد عبدالقادر، محمدنوبي طه عبدالقادر، الحسين غلاب جلال، محمد عبدالكريم حسن درويش، أيمن جمال عبد الراضي، موسى شوقي سالوس، سيدهم عبد الخالق محمد، أحمدعلي زين العابدين، محمد مصطفى محمد يس،مختار مراجع مختار، محمد مختار زكريا، أحمدعبدالعزيز إبراهيم عبدالصادق، جمال محمد محمد سليمان، مصطفى تاج الدين شهاب الدين، أحمد فوزي عبدالنبي القط،أنس محمد صفاءالدين شرشر، ياسر سيد إبراهيم قبيصي، يوسف محسن فلتاؤس، السيد لطفي السيد المصري، أشرف صلاح عبد الحميد، ياسر أحمد محمد الجوهري، محمد عمر الفاروق محمد، أمنية محمود المصيلحي،زينب أحمد عباس،أحمد محمد مصطفى رمضان،شيماء الدسوقي إبراهيم، إباء محمد علي خليفة،أحمدحسين أحمدحسين، مها أحمد محمد أحمد جادالله،أحمد محمد سليمان حسنين الفنة، عبدالفتاح محمد عبدالفتاح ناجي،وائل محمد عبدالحليم غانم، ولاء عبد ربه عبد العزيز الحاج، عماد فايق مرجان، دعاء أحمد محمد حمزة، هند حسن أحمد الفقي، أسعد رضا حسن إبراهيم، حنان عيسى إسماعيل، محمد عادل جودة، تاج الدين محمد علي شهاب الدين، مسعد محمد محمود عبدالعليم*، محروس عبدالغني محروس، محمد علي موسى عيد،أنور عبدالخالق عجيز،سامي رضا صابر صبري، محمد صفاء الدين شرشر، إيمان محمد محمد صادق، مصطفى عزب مصطفى،أسعد أحمد حمادة،صلاح الدين أحمد عبدالمجيد، أحمد محمد تمام،عزالدين عبدالرحمن محمد، حسن عبدالطيف حسن عشوش،هيام سيد محجوب، رضا محمد علي السيد قمبر، موريس بديع توفيليس، حمدي إبراهيم هنداوي، هاني سعد عبد الحميد البرهامي، عبدالسلام منشاوي، صباح حمزة أبوالعلا،نادية عدلي رياض،عبدالله عبدالمحسن سويلم،صبري أحمد محمد سليم، سعيد محمد حماد، محمد عبدالكريم إسماعيل خالد، سهير محمود حسن، سيد عبده الصاوي،رمضان عبدالسلام رمضان، جيهان عبدالواحد نورالدين عبدالرحمن، فرغل عبدالقادر مصطفى حفناوي، عبدربه عبدالعزيز أحمد الحاج، جمال عبدالرازق شعراوي، أحمد محمد أحمد جادالله،عزة محمد عبدالعال،عبدالفتاح عبدالرحمن مراد، محمد السيد السعيد صالح[1]،أسامة أحمد بعلط[2]، هبة إبراهيم سعد الدين[2] وعاطف عبد الفتاح شاهين[2].

[1] قسم بحوث القمح، معهد بحوث المحاصيل الحقلية، مركز البحوث الزراعية، الجيزة, مصر

[2] قسم بحوث أمراض القمح، معهد بحوث أمراض النباتات، مركز البحوث الزراعية،الجيزة, مصر

*بريد المؤلف المراسل:mossad_abdelaleem@hotmail.com

تم انتخاب صنف قمح الخبز المبكر الجديد سخا 96 من برنامج التربية، قسم بحوث القمح، معهد بحوث المحاصيل الحقلية، مركز البحوث الزراعية، مصر، في محطة البحوث الزراعية، سخا. مع الأخذ في الاعتبار صفات التبكير ومحصةل الحبوب المرتفع ومقاومة أمراض أصداء القمح الثلاثة. وتم تقييم الصنف الجديد على المستوى القومي في التجارب الأولية والمتقدمة والتجارب المزرعية، حيث بدأ التقييم في الموسم الزراعي 2018/2017 حتى الموسم الزراعي 2023/2022. أثبت الصنف الجديد تفوقه في صفات التبكير مقارنة بالأصناف التجارية خلال مراحل التقييم المتعاقبة في مواقع الدراسة. كما أنتج محصول حبوب جيد، في ميعاد الزراعة المتأخر، بالمقارنة بالأصناف التجارية غير المبكرة. كما كان للصنف الجديد درجات عالية من المقاومة لأمراض صدأ القمح الثلاثة في جميع مواقع ومواسم الزراعة المتعاقبة. وتم توصيف الصنف الجديد وتسجيله تبعا للاتحاد الدولي لحماية الأصناف النباتية الجديدة. ويوصي قسم بحوث القمح بزراعة الصنف الجديد سخا 96 كصنف تجاري لزراعته خاصة في موعد الزراعة المتأخرة.

الكلمات المفتاحية: القمح، خصائص التبكير، تاريخ الزراعة، محصول الحبوب.