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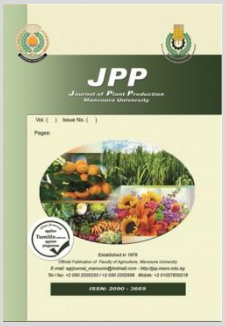
Comparison of the Effects of Different Sowing Methods on Yield and Yield Components of Some Newly released Bread Wheat Cultivars

Soliman, G. M. M.* and Y. S. I. Koubisy

Wheat Res. Dep., Field Crops Res. Inst, Agric. Res. Center, Giza, Egypt.



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ABSTRACT

This study was conducted during two consecutive growing seasons, 2023/2024 and 2024/2025 at Shandaweel Agricultural Research Station, Agricultural Research Center Egypt, to identify the most effective sowing methods for maximizing the productivity of newly released bread wheat cultivars. Four sowing methods, broadcast, drill, furrows and raising beds were evaluated alongside four bread wheat cultivars i.e. Sakha 95, Giza 171, Sids 15 and Misr 4. A split plot design with three replications was employed to assign the treatments. Sowing methods were allocated to the main plots and wheat cultivars were assigned to the sub-plots. The studied traits included: time to heading, days to physiological maturity, number of spikes m^{-2}, plant height, 1000-kernel weight, number of kernels $spike^{-1}$ and grain yield. Results indicated that the sowing methods had a significant or highly significant effect on all the examined characters in both seasons and their combined, except days to maturity in the 2nd season, plant height and 1000-kernel weight in both seasons. Wheat varieties also, showed a significant or highly significant differences for all the studied traits across both seasons and their combined, except for 1000-kernel weight in the 2nd season. The 1st order of interactions effect were significant or highly significant in most cases. Raised beds proved to the most effective sowing method, producing the highest grain yield with a mean of 8.91 tons $hectare^{-1}$, among the cultivars, Sakha 95 performed best under raised beds achieving the highest grain yield with an average of 9.58 tons $hectare^{-1}$.

Keywords: wheat, sowing methods and grain yield.

INTRODUCTION

Wheat is considered a key global food grain, and serves as a staple food for people worldwide (Ali et al., 2012). It is the world's most important crop, surpassing all other cereals in both cultivated area and total production. Often referred to as the 'King of Cereals,' wheat is one of the most nutritious grains and plays an essential role in sustaining humanity (Erenstein et al. 2022). Nutritious, wheat is rich in vitamins, minerals, and protein, supplying more than 60% of daily protein requirements and contributing more calories to human diet than any other food crop (Giraldo et al. 2019). Wheat is grown in large scale tropics and sub-tropics making it the main food crop of temperate zone. Bread wheat originated nearly 5000 years ago besides the Nile River civilization and spreads further to other valleys (Singh et al. 2024). Wheat provides roughly 20% of the daily calorie intake for nearly 55% of the global population (Bhaskar et al. 2022). By 2050, food consumption is likely to be twice as high as current levels (Abhishek et al. 2021). Wheat serves as Egypt's primary winter cereal crop and is cultivated extensively across the nation (Hefny 2017). The cultivated area of wheat in Egypt on the last season (2023-24) is approximately 3.254 million feddan (fed. = 4200 m-2), and the yield is about 9.431 million metric tons (Economic Affairs, Annual report, 2024). Wheat yield is influenced by multiple factors, including crop establishment methods, irrigation practices, sowing techniques, seed density, fertilizer application, and overall agronomic management. Among these, the sowing method plays a crucial role, as it directly affects the successful establishment of the crop stand. Additionally, optimal plant development relies on maintaining a balance in plant-to-plant competition (Bhaskar et al. 2022). Sowing techniques are a vital aspect of the soil's physical environment, influencing crop establishment, development, and productivity through their effects on root penetration, nutrient availability, and moisture uptake dynamics (Mollah et al. 2009). Traditional soil cultivation methods often fail to preserve the soil's physic-chemical characteristics and long-term sustainability. As a result, adopting alternative sowing techniques—such as bed planting and flat drilling—not only improves crop productivity but also supports soil health and environmental sustainability (Singh and Kaur 2019). Compared to drilling and broadcasting, the Raised Beds technique led to the highest grain yield for the wheat variety Misr-3 (Mohiy and Salous 2022). Ali et al. (2024) observed that the beds sowing method was the best sowing method of wheat which gave the notably raised all the examined means of traits relative to flat and drill sowing method. The augmented furrow (60 cm distance) was the better sowing method for wheat, (Zawar et al. 2024). All the evaluated characters were markedly impacted by the cultivation techniques and plant varieties (Hefny 2017). Wheat cultivars significantly affected grain yield (Mishra et al 2022). The goal of this examination was to establish the best sowing methods that give the highest crop productivity with modern bread wheat cultivars. The purpose of this examination was to establish the best sowing method that gives the highest productivity of the newly studied bread wheat varieties.

MATERIALS AND METHODS

A field experiment was conducted at Shandaweel Agricultural Research Station, Sohag governorate, Egypt, during two consecutive winter growing seasons 2023/2024 and 2024/2025 to evaluate the influence of different sowing methods on bread wheat cultivars. A split-block design with three replications was utilized with plot area 8.4 m2 (3.5 m length x 2.4 m width. Four sowing methods (broadcast, drill, furrows and beds) were allocated in the chief plots and four wheat varieties (Sakha95, Giza171, Sids 15 and Misr4) were allocated in the sub plots, the pedigree and the selection

* **Corresponding author.**
E-mail address: dr_gamal.soliman@yahoo.com
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history of these cultivars are presented in Table 1. According to the recommendations, seeding rates and all the other agricultural practices were implemented. The sowing dates were 22 and 25 November in the 1st and the 2nd season, respectively. The mini, maxi and mean air temperature for the two growing seasons, are shown in Table 2. Table 3 displays the soil's chemical and physical characteristics prior to planting in both growing seasons.

Table 1. The pedigree and breeding history of the investigated bread wheat varieties.

Genotypes	Pedigree and Selection History
Sakha 95	PASTOR // SITE/MO /3/CHEN/AEGILOPS SQUARROSA (TAUS)// BCN /4/ WBLL1 CMSA01Y00158S-040P0Y-040M-030ZTM-040SY-26M-0Y-0SY-0S
Giza 171	Sakha 93/Gemmiza 9 Gz 2003-101-1 Gz- 4 Gz- 1 Gz- 2 Gz- 0 Gz
Sids 15	PARUS/PASTOR//FIDIYA-20/3/PASTOR//MILAN/KAUZ ICW 11-20063-2AP-0TR-1TR-0SD
Misr 4	NS732/HER/3/PRL/ SARA// TSI/VEE 5/6/FRET 2/5/WHEAR/SOKOLL CM SA09Y007125-050Y- 050ZTM-0NJ-099NJ-0B-0EG

Table 2. The mini, maxi. and average air temperature throughout the two growing seasons 2023/2024 and 2024/2025:

Season	Item	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
23-24	Mini.	11.7	10.2	7.5	8.2	12.1	17.2
	Maxi.	24.8	23m.1	20.4	21.6	26.9	32.3
	Mean	17.7	16.2	13.6	14.9	19.3	24.8
24-25	Mini.	10.4	7.8	8.9	6.5	12.5	17.0
	Maxi.	22.1	20.7	22.0	19.7	27.0	30.6
	Mean	16.1	13.8	14.9	13.1	19.7	23.8

Table 3. The physical and chemical attributes of the soil before planting:

Item	2023/24	2024/25	Item	2023/24	2024/25
PH	7.77	7.78	Soluble Cations (meq/L)		
EC ds/m	0.21	0.21	Ca^{+2}	0.72	0.66
OM%	0.66	0.68	Mg^{+2}	0.43	0.47
Particles size distribution%			Na^{+}	0.74	0.77
Sand%	23.70	25.36	K^{+}	0.34	0.33
Silt%	38.68	39.16	Soluble Anions (meq/L)		
Clay%	37.62	38.48	HCO_3^{-}	1.06	0.99
Texture class	Clay loam	Clay loam	Cl^{-}	0.60	1.00
Soil water content%			SO_4^{-2}	0.38	0.32
SP	52.00	53.00	Available Macro-Nutrients (ppm)		
FC	25.33	25.48	N	49.00	51.00
WP	12.88	12.90	P	15.45	16.85
			K	321.00	333.00

Recorded data:

The examined characters were period to heading (days), days to maturity (days), count of spikes m-2 (spike), plant height (cm), 1000-kernel weight (g), number of kernels spike-1 (kernel) and grain yield (tons hectare-1).

Statistical analysis:-

Each season was analyzed separately using variance analysis. The homogeneity of error variances across seasons was tested using Bartlett (1937). A basic relationship between the chosen parameters was determined by employing Ms-Excel. Data collected were analyzed utilizing the Statistical package GENSTAT (GenStat 19th edition, GenStat-VSN International, Hemel Hempstead, UK). The analysis of variance (ANOVA) was conducted and means values evaluated through the least significant difference (LSD) test at a 5% probability level (Steel *et al.,* 1997).

RESULTS AND DISCUSSIONS

For all traits examined except days to maturity and kernels per spike, significant or highly significant differences were observed between the two growing seasons. The maximum, minimum and averages of air temperatures during the two growing seasons 2023/2024 and 2024/2025 are presented in Table 3. In general, the temperatures during the 1st growing season are higher than the 2nd growing season, especially at the beginning of the season (November and December months) at the tillering stage, this led to decreasing in the total count of spikes m^{-2} trait which considered one of the component of grain yield. This resulting in decreasing the grain yield in the 1st season compared to the 2nd season.

1- Number of days to heading:

The data on the number of days to heading are displayed in Table 4.

Sowing methods effect:

The number of days to heading was notably influenced by sowing methods across both seasons and in their combined analysis. The latest heading was noted by the broadcast method relative to the other sowing approaches with averages of 89.58, 87.50, 85.92 and 86.33 days for broadcast, drill, furrows and beds sowing methods, in the 1st season, respectively. The mean values of days to heading for these sowing methods in the 2nd season were 91.92, 91.00, 88.75 and 89.33 days, respectively. Terfa et al (2020) documented that the mean count of days to 50% heading of bread wheat was extremely significantly ($P<0.01$) impacted by the main impact of sowing method.

Differences between wheat cultivars:

The differences among wheat cultivars were greatly significant in average count of days to heading in both seasons and their combined. The cultivar Sids 15 was the earliest cultivar in average time to heading with an averages

The interaction effect

The interaction impact among sowing procedures and varieties was insignificant in the 1st season, whereas it was remarkably high in the 2nd season. Moreover, combined analysis displayed significant or greatly significant differences among seasons × cultivars, sowing methods × cultivars and seasons × sowing methods × cultivars interactions. The interaction between seasons × sowing methods was insignificant. The minimum period for days to heading were noted for the cultivar Sids 15 in the 1st season with an averages of 83.33 and 83.67 days under furrows and beds sowing methods, respectively, while the longest period for days to heading were recorded for the cultivar Misr 4 in the 2nd season with an averages of 94.67 and 95 days under broadcast and furrows sowing methods, respectively. Terfa *et al* (2020) stated that the two-way interaction of wheat cultivars with sowing methods showed significant ($p<0.05$) impact on the days to 50% heading of wheat.

1- Number of days to maturity:

The data on the count of days to maturity are displayed in Table 4.

Sowing methods effect:

The count of days to maturity was insignificantly influenced by sowing methods in the 2nd season and greatly significant in the 1st season and their combined. The latest maturity was recorded by the broadcast method compared to the other sowing methods with an averages of 147.50, 143.42, 144.33 and 145.33 days for broadcast, drill, furrows and beds sowing methods, in the 1st season, respectively. Conversely, the mean values of days to maturity for these sowing methods in the 2nd season were 144.00, 143.67, 143.83 and 144.17 days, respectively. The delaying in heading and maturity for broadcast sowing method may be due to the heterogeneity

germination of wheat kernels when planting as resulted by the heterogeneity of the depth of wheat kernels when planting by broadcast method comparing with the other studding sowing methods by placing wheat kernels in a determined depth. Terfa *et al* (2020) found that the chief impact of sowing methods showed a greatly significant ($p<0.01$) impact on days to physiological maturity.

Table 4. Average days to heading and maturity for four wheat varieties as influenced by sowing methods across two seasons and their combined analysis.

Sowing methods	Traits	Days to heading			Days to maturity		
	Season Cultivar	2023/2024	2024/2025	Mean	2023/2024	2024/2025	Mean
Broadcast	Sakha 95	90.00	89.33	89.67	146.00	141.33	143.67
	Giza 171	88.00	93.00	90.50	146.67	145.00	145.83
	Sids 15	87.33	90.67	89.00	147.00	144.00	145.50
	Misr 4	93.00	94.67	93.83	150.33	145.67	148.00
	Mean	89.58	91.92	90.75	147.50	144.00	145.75
Drill	Sakha 95	88.00	91.67	89.83	142.33	142.00	142.17
	Giza 171	86.00	90.00	88.00	143.67	142.67	143.17
	Sids 15	85.00	87.33	86.17	142.00	144.33	143.17
	Misr 4	91.00	95.00	93.00	145.67	145.67	145.67
	Mean	87.50	91.00	89.25	143.42	143.67	143.54
Farrows	Sakha 95	88.33	89.00	88.67	144.00	142.67	143.33
	Giza 171	83.67	88.00	85.83	143.00	143.33	143.17
	Sids 15	83.33	86.00	84.67	143.67	144.00	143.83
	Misr 4	88.33	92.00	90.17	146.67	145.33	146.00
	Mean	85.92	88.75	87.33	144.33	143.83	144.08
Beds	Sakha 95	86.67	90.33	88.50	144.00	143.33	143.67
	Giza 171	85.00	89.00	87.00	144.67	143.00	143.83
	Sids 15	83.67	86.00	84.83	146.33	144.00	145.17
	Misr 4	90.00	92.00	91.00	146.33	146.33	146.33
	Mean	86.33	89.33	87.83	145.33	144.17	144.75
General Mean		87.33	90.25	88.79	145.15	143.92	144.53
Means of wheat cultivars	Sakha 95	88.25	90.08	89.17	144.08	142.33	143.21
	Giza 171	85.67	90.00	87.83	144.50	143.50	144.00
	Sids 15	84.83	87.50	86.17	144.75	144.08	144.42
	Misr 4	90.58	93.42	92.00	147.25	145.75	146.50

		2023/2024		2024/2025		Combined		2023/2024		2024/2025		Combined	
	Effect	F test	LSD 0.05	F test	LSD 0.05	F test	LSD 0.05	F test	LSD 0.05	F test	LSD 0.05	F test	LSD 0.05
Combined analysis	C	**	1.52	**	1.13	**	0.84	**	0.69	**	0.96	**	0.53
	SM	**	0.99	**	1.02	**	0.63	**	1.370.69	ns	---	**	0.69
	C × SM	ns	---	**	1.60	**	1.18	ns	---	ns	---	ns	---
	S					*	2.40					ns	---
	S × C					*	2.36					ns	---
	S × SM					ns	---					**	2.69
	S × C × SM					**	2.52					ns	---
C. V.		0.9		0.9		0.9		0.8		0.8		0.8	

ns: non-significant.* and **: significant at 0.05 and 0.01 levels of probability, respectively.of 84.83 and 87.50 days in the 1st and the 2nd season, respectively. Conversely, the cultivar Misr 4 was the latest cultivar in both seasons with averages of 90.58 and 93.43 days in the 1st and the 2nd season, respectively. Abd El-Rady *et al* (2020) noted significant differences among cultivars for time to heading in both seasons and their combined analysis. Geleta (2024) found that bread wheat varieties showed significant (P<0.05) variation in the count of days to 50% heading.

Differences between wheat cultivars:

A highly significant effect was found between wheat cultivars in the average time to maturity in both seasons and their combined. The cultivar Sakha 95 was the earliest cultivar in the average count of days to maturity in both seasons and over seasons with an averages of 144.08, 142,33 and 143.21 days in the 1st, the 2nd season and the mean of the two seasons, respectively. Conversely, the cultivar Misr 4 was the latest cultivar in both seasons with an average of 147.25, 145.75 and 146.50 days in the 1st, the 2nd and the mean of the two seasons, respectively. Terfa *et al* (2020) noted that the main effect of wheat varieties showed a greatly significant ($p<0.01$) impact on days to physiological maturity.

The interaction impact

The 1st order interaction effect of time to maturity by sowing methods and cultivars was insignificant in both seasons. Likewise, the combined analysis demonstrated greatly substantial differences just across seasons and sowing methods, while the other interactions were insignificant, this means that each of sowing methods and wheat cultivars had a strong effect in average number of days to maturity but there aren't interactions. The shortest period for days to maturity were documented for the cultivar Sakha 95 in the 2nd season with an average of 141.33 days, while the longest period for time to maturity were documented for the cultivar Misr 4 in the 1st season with a mean of 150.33 days under broadcast sowing method. Terfa *et al* (2020) cleared that the two-way interaction of wheat cultivars with sowing method was significantly ($p<0.05$) impacted days to physiological maturity of wheat.

2- Plant height:

Table 5 presents the data on plant height.

Sowing methods effect:

Plant height insignificantly influenced by sowing methods in the two seasons and their combined. The tallest wheat plants were recorded by the bed method compared to the other sowing methods with an average of 110.25, 110.42, 110.67 and 111.25 cm for broadcast, drill, furrows and beds sowing methods, in the 1st season, respectively. Conversely, the mean values of plant height for these sowing methods in the 2nd season were 117.33, 116.83, 117.33 and 115.00 cm, respectively. Hefny (2017) found that the planting methods had significantly impact on plant height in both seasons. Singh and Kaur (2019) cleared that Bed planting method

produced significantly higher plant height than happy seeder and zero tillage sowing. Ali *et al* (2024) stated that plant height was significantly increased in bed sowing method.

Differences among wheat cultivars:

A highly significant difference was detected between wheat cultivars in the average of plant height in the two seasons and their combined. The cultivar Misr 4 was the shortest cultivar in average the height of the plant in the two seasons and over seasons with an averages of 107.42, 111.83 and 109.62 cm in the 1st, the 2nd season and the mean of the two seasons, respectively. Conversely, the cultivar Giza 171 was the tallest in the 1st season with an average of 113.17 cm, while in the 2nd season, the cultivars Sakha 95 and Sids 15 was the tallest with an average of 118.42 and 118.33 cm, respectively. Over all seasons, the cultivars Sakha 95, Giza 171 and Sids 15 were close together with an averages of 115.33, 115.54 and 114.04 cm, respectively. Hefny (2017) found that the varieties had significant impact on plant height in both seasons. Bhatti *et al* (2022) reported that the impact of wheat cultivars on plant height was significant.

Table 5. Effects of sowing methods on plant height and spike density (spikes m^{-2}) in four wheat varieties across two growing seasons and their combined analysis.

Sowing methods	Traits	Plant height			Number of spikes m^{-2}		
	Season Cultivar	2023/2024	2024/2025	Mean	2023/2024	2024/2025	Mean
Broadcast	Sakha 95	112.00	118.33	115.17	406.1	483.3	444.7
	Giza 171	113.67	119.00	116.33	378.1	444.0	411.1
	Sids 15	110.00	119.67	114.83	445.9	555.3	500.6
	Misr 4	105.33	112.33	108.83	381.6	494.0	437.8
	Mean	110.25	117.33	113.79	402.9	494.2	448.5
Drill	Sakha 95	109.33	118.00	113.67	406.4	493.3	449.9
	Giza 171	112.33	119.67	116.00	380.8	453.3	417.1
	Sids 15	109.33	118.00	113.67	428.3	566.7	497.5
	Misr 4	110.67	111.67	111.17	406.4	496.7	451.5
	Mean	110.42	116.83	113.62	405.5	502.5	454.0
Farrows	Sakha 95	114.00	121.67	117.83	369.1	458.7	413.9
	Giza 171	115.00	116.33	115.67	323.2	365.3	344.3
	Sids 15	109.00	120.00	114.50	363.2	473.3	418.3
	Misr 4	104.67	111.33	108.00	365.3	458.7	412.0
	Mean	110.67	117.33	114.00	355.2	439.0	397.1
Beds	Sakha 95	113.67	115.67	114.67	390.4	462.7	426.5
	Giza 171	111.67	116.67	114.17	333.9	373.3	353.6
	Sids 15	110.67	115.67	113.17	348.8	474.7	411.7
	Misr 4	109.00	112.00	110.50	362.7	457.3	410.0
	Mean	111.25	115.00	113.12	358.9	442.0	400.5
General Mean		110.65	116.62	113.64	380.6	469.4	4.25.0
The means of wheat cultivars	Sakha 95	112.25	118.42	115.33	393.0	474.5	433.7
	Giza 171	113.17	117.92	115.54	354.0	409.0	381.5
	Sids 15	109.75	118.33	114.04	396.5	517.5	457.0
	Misr 4	107.42	111.83	109.62	379.0	476.7	427.8

		2023/2024		2024/2025		Combined		2023/2024		2024/2025		Combined	
	Effect	F test	LSD 0.05	F test	LSD 0.05	F test	LSD 0.05	F test	LSD 0.05	F test	LSD0.05	F Test	LSD 0.05
Combined analysis	C	**	1.51	**	2.47	**	1.29	**	17.95	**	22.14	**	12.69
	SM	ns	---	Ns	---	ns	---	**	18.52	**	11.41	**	9.69
	C × SM	ns	---	Ns	---	ns	---	*	29.06	**	24.97	**	18.50
	S					**	3.18					**	10.00
	S × C					*	3.16					**	16.96
	S × SM					ns	---					ns	---
	S × C × SM					ns	---					ns	---
C. V.		4.06		1.10		3.22		4.30		2.10		3.20	

ns: non-significant. * and **: significant at 0.05 and 0.01 levels of probability, respectively.

The interaction impact

The interaction impact for plant height among sowing methods and cultivars was insignificant in the two seasons. Furthermore, combined analysis overall, significant differences displayed just among seasons × cultivars, while the other interactions were insignificant. The shortest plants were recorded for the variety Misr 4 using broadcast and furrows sowing methods in the 1st season with averages of 105.33 and 104.67 cm, while the longest plants were recorded for the variety Sakha 95 in the 2nd season with an average of 121.67 cm under furrows sowing method. Bhatti *et al* (2022) stated that the impact of the interaction among sowing approaches and wheat cultivars on plant height was significant. Geleta (2024) reported that the interactive impacts of wheat cultivars with sowing process was significantly ($P<0.01$) influenced the plant height of bread wheat.

3- Number of spikes m^{-2}:

Data on the number of spikes m^{-2} are presented in Table 5.

Sowing methods effect:

Sowing methods had a highly notable impact on the count of spikes m^{-2} in the two seasons and their combined. The maximum number of spikes m^{-2} was recorded by the drill method compared to the other sowing methods with an averages of 402.9, 405.5, 355.2 and 358.9 spike for broadcast, drill, furrows and beds sowing methods, in the 1st season, respectively. Conversely, the mean values of the count of spikes m^{-2} for these sowing methods in the 2nd season were 494.2, 502,5, 439.0 and 442.0 spike, respectively. Hefny (2017) reported that the planting methods showed meaningfully impact on the count of spikes m^{-2} in both seasons. The increase percentage in the number of spikes m^{-2} due to drill compared to broadcast sowing methods were 2.35 and 12.53% in both seasons, respectively (Mosalem *et al* 2021). Abhishek *et al* (2021) stated that seed drill showed the highest number of tillers (400.50 m^{-2}), which demonstrated significantly better results than all other treatments.

Differences between wheat cultivars:

Wheat varieties demonstrated a highly significant impact on the average count of spikes m^{-2} in both seasons and

their combined. The cultivar Giza 171 was the least cultivar in the average count of spikes m^{-2} in both seasons and over seasons with averages of 354.0, 409.0 and 381.5 spikes in the 1st, the 2nd season and the mean of the two seasons, respectively. Conversely, the cultivar Sids 15 was the maximum cultivar in the average number of spikes m^{-2} in both seasons and over seasons with averages of 396.5, 517.5 and 457.0 spikes in the 1st, the 2nd season and the mean of the two seasons, respectively. Hefny (2017) found that the varieties had significantly differed in the count of spikes m^{-2} in the two seasons. Khatri *et al* (2019) stated that there was significant impact of wheat cultivars on number of tillers m^{-2}. Mishra *et al* (2022) established the significant impact of wheat varieties on the count of tillers m^{-2}.

The interaction effect

The interaction effect among sowing methods and cultivars for the count of spikes m^{-2} was substantial in the 1st season and greatly notable in the 2nd season. Furthermore, combined analysis overall, extremely significant differences were shown among seasons × cultivars and sowing methods × cultivars, whereas the interactions among seasons × sowing methods and seasons × sowing methods × cultivars were insignificant. The least count of spikes m^{-2} was recorded for the cultivar Giza 171 using furrows sowing method in the 1st season with an average of 323.2 spike, while the maximum number of spikes m^{-2} were recorded for the cultivar Sids 15 in the 2nd season with an averages of 555.3 and 566.7 spikes under broadcast and drill sowing procedures. Bhatti *et al* (2022) reported that the impact of the interaction among sowing procedures and wheat cultivars on number of spikes m^{-2} was significant. Mohiy and Salous (2022) observed that the combination of seasonal variations and planting techniques had a notable impact on the count of spikes m^{-2}.

4- 1000-Kernel weight

Data of 1000-kernel weight are displayed in Table 6.

Sowing methods effect:

1000-kernel weight influenced insignificantly by sowing methods in both seasons and their combined. The heaviest 1000-kernel weight was recorded by the beds method relative to the other sowing methods with an averages of 50.95, 51.13, 51.25 and 51.35 g for broadcast, drill, furrows and beds sowing methods, in the 1st season, respectively. Conversely, the mean values of 1000-kernel weight for these respective sowing methods in the 2nd season were 55.73, 55.25, 55.90 and 55.33 g. It's cleared that the furrows sowing method had the heaviest 1000-kernel weight in the 2nd season relative to the other sowing methods. Terfa *et al* (2020) found that 1000-kernel weight significantly ($P<0.05$) impacted by the chief impact of sowing method, the increase percentage in 1000-kernel weight due to drill compared to broadcast sowing methods were 5.11 and 6.94% in both seasons, respectively (Mosalem *et al* 2021). Ali *et al* (2024) stated that 1000 grain weight was meaningfully increased in bed sowing method.

Differences between wheat cultivars:

Significant differences were recorded across wheat cultivars in the average 1000-kernel weight during the 1st season, while the effect of wheat cultivars in the 2nd season was insignificant, conversely, the combined between the two seasons was highly significant. The cultivar Giza 171 was the lightest cultivar in average 1000-kernel weight in the two seasons and over seasons with an averages of 49.97, 54.50 and 52.23 g in the 1st, the 2nd season and the mean of the two seasons, respectively. Conversely, the cultivar Sakha 95 was the heaviest cultivar in average 1000-kernel weight in both seasons and over seasons with averages of 52.23, 56.63 and 54.43 g in the 1st, the 2nd season and the mean of the two seasons, respectively. Hassan *et al* (2021) found that wheat cultivars showed a notable impact on 1000-grain weight in both seasons. Geleta (2024) found that the key impact of cultivars demonstrated a significant ($P<0.05$) influence on 1000-grain weight.

The interaction effect

The interaction effect for 1000-kernel weight between sowing methods and cultivars was substantial in the two seasons. Furthermore, combined analysis overall, extremely significant differences showed just among sowing methods × cultivars, while the other interactions were insignificant. The lightest 1000-kernel weight was recorded for the cultivar Giza 171 under drill sowing method in the 1st season with an averages of 47.80 g, whereas the heaviest 1000-kernel weight were recorded for the cultivar Sakha 95 in the 2nd season with an averages of 57.13 and 57.00 g under furrows and beds sowing methods. Bhatti *et al* (2022) stated that the influence of the interaction among sowing approaches and wheat cultivars on 1000-kernel weight was significant. Geleta (2024) reported that the two-way interaction of wheat cultivars with sowing methods was demonstrated significant ($P<0.05$) impact on thousand grain weight.

5- Number of kernels spike^{-1}:

Data on the number of kernels spike^{-1} are presented in Table 6.

Sowing methods effect:

The sowing methods showed a significant or extremely significant impact on the count of kernels spike^{-1} in the two seasons and their combined. The highest count of kernels spike^{-1} was recorded by the furrows method relative to the other sowing methods with an averages of 30.23, 31.37, 35.48 and 32.68 kernel for broadcast, drill, furrows and beds sowing methods, in the 1st season, respectively. Conversely, the mean values of count of kernels spike^{-1} for these sowing methods in the 2nd season were 33.28, 32.44, 36.69 and 37.23 kernel, respectively, it's cleared that beds sowing method showed the uppermost count of kernels spike^{-1} in the 2nd growing season. Over all seasons furrows sowing method had the maximum number of kernels spike^{-1} with an average of 36.08 kernels relative to the other sowing approaches. According to Abdul-Razaq *et al*. (2019), cultivating crops on raised beds produced a greater grain count per spike relative to traditional flat bed sowing methods. Terfa *et al* (2020) observed that the count of kernels per spike was meaningfully influenced ($P < 0.05$) by the sowing method as a main effect. Singh *et al* (2024) documented that furrows sowing method was best practice to get the best performance in form of number of kernels spike^{-1} relative to broadcast.

Differences between wheat cultivars:

The wheat varieties showed a significant or extremely significant influence on the mean count of kernels per spike across both growing seasons as well as in their combined analysis. The cultivars Misr 4 was the least cultivar in average number of kernels spike^{-1} in the 1st season with an average of 31.01 kernel and the cultivar Sids 15 was the least cultivar in average number of kernels spike^{-1} in the 2nd season and over seasons with an averages of 31.70 and 31.20 kernel, respectively. Conversely, the cultivar Giza 171 was the highest cultivar in the average count of kernels spike^{-1} in the two seasons and over seasons with averages of 35.16, 39.28 and 37.22 kernel in the 1st, the 2nd season and the mean of the two seasons, respectively. Hassan *et al* (2021) stated that Wheat cultivars showed a notable impact on the count of grains spike^{-1} in the two seasons.

Table 6. Means of number of 1000-kernel weight and number of kernels spike^{-1} of four wheat varieties as influenced by sowing methods in the two seasons and their combined analysis.

Sowing methods	Traits	1000-Kernel weight			Number of kernels spike^{-1}		
	Season Cultivar	2023/2024	2024/2025	Mean	2023/2024	2024/2025	Mean
Broadcast	Sakha 95	50.53	55.53	53.03	30.53	35.87	33.20
	Giza 171	50.73	55.33	53.03	29.55	36.95	33.25
	Sids 15	51.00	56.07	53.53	27.17	29.64	28.41
	Misr 4	51.53	56.00	53.77	33.68	30.67	32.17
	Mean	50.95	55.73	53.34	30.23	33.28	31.76
Drill	Sakha 95	53.20	56.87	55.03	31.62	33.27	32.44
	Giza 171	47.80	52.00	49.90	35.79	37.24	36.52
	Sids 15	50.53	55.53	53.03	28.95	27.44	28.19
	Misr 4	53.00	56.60	54.80	29.11	31.82	30.46
	Mean	51.13	55.25	53.19	31.37	32.44	31.90
Farrows	Sakha 95	53.00	57.13	55.07	36.48	36.89	36.68
	Giza 171	50.73	55.67	53.20	40.65	42.67	41.66
	Sids 15	50.00	54.80	52.40	33.05	33.07	33.06
	Misr 4	51.27	56.00	53.63	31.75	34.11	32.93
	Mean	51.25	55.90	53.57	35.48	36.69	36.08
Beds	Sakha 95	52.20	57.00	54.60	31.34	37.55	34.45
	Giza 171	50.60	55.00	52.80	34.66	40.25	37.45
	Sids 15	50.13	53.20	51.67	35.21	35.04	35.13
	Misr 4	52.47	56.13	54.30	29.52	36.08	32.80
	Mean	51.35	55.33	53.34	32.68	37.23	34.96
General Mean		51.17	55.55	53.36	32.44	34.91	33.68
The means of wheat cultivars	Sakha 95	52.23	56.63	54.43	32.49	35.89	34.19
	Giza 171	49.97	54.50	52.23	35.16	39.28	37.22
	Sids 15	50.42	54.90	52.66	31.10	31.70	31.20
	Misr 4	52.07	56.18	54.12	31.01	33.17	32.09

		2023/2024		2024/2025		Combined		2023/2024		2024/2025		combined	
	Effect	F test	LSD 0.05	F test	LSD 0.05	F test	LSD 0.05	F test	LSD 0.05	F test	LSD0.05	F Test	LSD 0.05
Combined analysis	C	*	1.54	ns	---	**	1.03	*	2.80	**	3.30	**	1.90
	SM	ns	---	ns	---	ns	---	**	1.60	*	3.00	**	1.50
	C × SM	*	2.05	*	2.34	**	1.52	**	3.70	ns	---	**	2.90
	S					**	0.38					ns	---
	S × C					ns	---					ns	---
	S × SM					ns	---					ns	---
	S × C × SM					ns	---					*	5.70
C. V.		2.40		2.30		2.40		6.50		6.20		6.30	

ns: non-significant. * and **: significant at 0.05 and 0.01 levels of probability, respectively.

The interaction effect

The interaction effect among sowing procedures and cultivars for the count of kernels spike^{-1} was greatly important in the 1st season, whereas it was insignificant in the 2nd season. Moreover, combined analysis over all cleared that extremely significant differences were showed between sowing methods × cultivars and significant between seasons × sowing methods × cultivars, while the interactions among seasons × sowing methods and seasons × cultivars were insignificant. The least number of kernels spike^{-1} were recorded for the cultivar Sids 15 using broadcast and drill sowing methods in the 1st and the 2nd season with an averages of 27.17 and 27.44 kernel, respectively, while the uppermost number of kernels spike^{-1} were noted for the variety Giza 171 in the 2nd season with an averages of 42.67 kernel under furrows sowing method. Bhatti *et al* (2022) stated that the impact of the interaction among sowing procedures and wheat varieties on number of kernels spike^{-1} was significant. Geleta (2024) cleared that the interaction of varieties with sowing methods significantly ($P<0.05$) affects the count of kernels spike^{-1} of bread wheat.

6- Grain yield:

Data of grain yield (ton/ha) are displayed in Table 7.

Sowing methods effect:

Grain yield is affected significantly or highly significantly by sowing methods in the two seasons and their combined. The maximum grain yield was recorded by the furrows and the beds sowing methods relative to the other sowing methods with an averages of 7.47, 7.72, 8.04 and 8.09 tons/ha for broadcast, drill, furrows and beds sowing methods, in the 1st season, respectively. Conversely, the mean values of grain yield for these sowing methods in the 2nd season were 8.35, 8.63, 8.79 and 8.91 tons/ha, respectively. Over seasons, it's cleared that both furrows and beds sowing methods have the heaviest grain yield relative to the other sowing approaches. The main problem in many soils specially the heavy clay soil and the soil which located in the delta of the river Nile is the logging which the inability of soil to absorb water which led to decrease the oxygen gas in the soil, resulted in decrease the growth of the root system and decrease in its function of absorbing water and nutrients which wheat plants need to growth and complete its life circle and produce more of grain yield. Using furrows or beds sowing methods is one of the important solutions to overcome this problem because it's led to improving the ventilation of the soil. According to Singh and Kaur (2019), bed planting demonstrated a 14% higher grain yield compared to the Happy Seeder and a 10.48% increase over zero-tillage sowing. Terfa *et al* (2020) documented that the sowing method showed a significant ($P < 0.05$) impact on grain yield. Mosalem *et al* (2021) indicated that the rise percentage in grain yield owing to rows compared to broadcast sowing methods were 8.02 and 7.74% in both seasons, respectively. Ali *et al* (2024) stated that grain yield was significantly raised in bed sowing method.

Differences between wheat cultivars:

A significant or extremely significant differences were recorded across wheat varieties in average grain yield in the 1st, the 2nd season and its combined. The cultivars Giza 171, Sids 15 and Misr 4 were closer in average grain yield in

the two seasons and over seasons. Conversely, the cultivar Sakha 95 was the highest cultivar in average grain yield in both seasons and over seasons with averages of 8.31, 10.11 and 9.21 tons in the 1st, the 2nd season and the mean of the two seasons, respectively. Hassan *et al* (2021) noted that Wheat cultivars showed a notable impact on grain yield in the 1st growing season. Geleta (2024) reported that the main impacts of cultivars were significantly (P<0.05) impacted the grain yield of bread wheat.

Table 7. Means of grain yield (ton/ha) of four wheat varieties as influenced by sowing methods in the two seasons and its combined analysis.

Sowing methods	Traits / Season / Cultivar	Grain yield (ton/ha) 2023/2024	2024/2025	Mean
Broadcast	Sakha 95	7.97	9.60	8.78
	Giza 171	7.28	9.05	8.17
	Sids 15	7.64	9.23	8.44
	Misr 4	6.97	9.08	8.02
	Mean	7.47	9.24	8.35
Drill	Sakha 95	7.82	9.92	8.87
	Giza 171	7.03	9.43	8.23
	Sids 15	7.72	9.24	8.48
	Misr 4	8.32	9.60	8.96
	Mean	7.72	9.55	8.63
Farrows	Sakha 95	8.91	10.32	9.61
	Giza 171	8.32	9.33	8.82
	Sids 15	7.50	9.18	8.34
	Misr 4	7.42	9.38	8.40
	Mean	8.04	9.55	8.79
Beds	Sakha 95	8.54	10.62	9.58
	Giza 171	8.14	8.88	8.51
	Sids 15	7.83	9.50	8.67
	Misr 4	7.83	9.95	8.89
	Mean	8.09	9.73	8.91
General Mean		7.83	9.52	8.67
The means of wheat cultivars	Sakha 95	8.31	10.11	9.21
	Giza 171	7.70	9.17	8.43
	Sids 15	7.67	9.28	8.48
	Misr 4	7.63	9.50	8.57

Combined analysis		2023/2024		2024/2025		Combined	
	Effect	F test	LSD 0.05	F test	LSD 0.05	F test	LSD 0.05
	C	**	0.26	*	0.48	**	0.24
	SM	**	0.28	*	0.28	**	0.18
	C × SM	**	0.41	*	0.58	**	0.35
	S					**	0.16
	S × C					ns	---
	S × SM					ns	---
	S × C × SM					**	0.48
C. V.		3.10		2.90		3.00	

ns: non-significant. * and **: significant at 0.05 and 0.01 levels of probability, respectively.

The interaction effect

The interaction among sowing approaches and cultivars showed a highly significant impact on grain yield in the 1st season, whereas it was only significant in the second season. Moreover, combined analysis over all cleared that extremely significant differences were shown between sowing methods × cultivars and seasons × sowing methods × cultivars, while the interactions among seasons × sowing methods and seasons × cultivars were insignificant. The least grain yield was recorded for the cultivar Misr 4 under broadcast sowing method and the cultivar Giza 171 under drill sowing method in the 1st season with an averages of 6.97 and 7.03 tons, respectively, while the maximum grain yield was noted for the variety Sakha 95 in the 2nd season with an averages of 10.32 and 10.62 tons under furrows and beds sowing methods. Terfa *et al* (2020) reported that the interaction among wheat varieties and sowing methods exhibited a highly significant impact (P < 0.01) on the average grain yield of bread wheat.

7- Correlation

The correlation coefficient between all possible pairs of traits is displayed in Table 8. growth, yield, and yield component parameters were presence.

Table 8. The correlation coefficient between all possible pairs of traits

	Days to heading	Days to maturity	Plant height	Number of spikes m^{-2}	1000-Kernel weight	Number of kernels $spike^{-1}$	Grain yield
Days to maturity	0.37**	-					
Plant height	0.08	-0.29**	-				
Number of spikes m^{-2}	0.44**	-0.14	0.41**	-			
1000-Kernel weight	0.52**	-0.19*	0.42**	0.62**	-		
Number of kernels $spike^{-1}$	-0.04	-0.25**	0.24*	-0.29**	0.06	-	
Grain yield	0.35**	-0.37**	0.57**	0.58**	0.78**	0.33**	-

The correlation coefficient among grain yield and the other characters were positive and highly significant with all the other examined characters except with days to maturity the correlation coefficient was negative and highly significant. The highest correlation coefficient among grain yield and the other examined characters was with 1000-kernel weight (0.78**), this means that 1000-kernel weight in this study was the most influential traits in the grain yield, also, the correlation coefficients among grain yield and its other components were positive and extremely significant. The correlation coefficients among grain yield and each of days to heading and plant height was positive and highly significant because whenever the plants take long time in the vegetative stage it will have big and strong plants (tall plants) this will

increase the photosynthesis process and increase the dry matter which cause increasing the grain yield. Geleta (2024) reported that strong positive and significant ($P \leq 0.01$) associations among growth, yield, and yield component parameters were presence.

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مقارنة تأثير بعض طرق الزراعة على المحصول ومكوناته لبعض أصناف قمح الخبز

جمال محمد محمد سليمان و ياسر سيد إبراهيم قبيصي

قسم بحوث القمح - معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية - الجيزة - مصر

الملخص

تم تنفيذ هذه الدراسة خلال الموسمين الزراعيين ٢٠٢٣/٢٠٢٤ و٢٠٢٤/٢٠٢٥م في محطة البحوث الزراعية بشندويل – مركز البحوث الزراعية – مصر بهدف تحديد أفضل طرق الزراعة والتي تعطي أعلى إنتاجية مع أصناف القمح الحديثة. تم استخدام أربعة طرق للزراعة في هذه الدراسة وهي: البدار والتسطير والخطوط والمصاطب وأربعة أصناف من قمح الخبز وهي سخا ٩٥ وجيزة ١٧١ وسدس ١٥ ومصر ٤. كان التصميم المستخدم في هذا البحث هو تصميم القطع المنشقة مرة واحدة مع استعمال ثلاث مكررات. تم وضع طرق الزراعة في القطع الرئيسية ووضع أصناف القمح في القطع المنشقة. الصفات المدروسة هي عدد الأيام حتى طرد السنابل وعدد الأيام حتى النضج الفسيولوجي وعدد السنابل في المتر المربع وارتفاع النبات ووزن الألف حبة وعدد حبوب السنبلة ومحصول الحبوب. أظهرت النتائج أن طرق الزراعة كان لها تأثير معنوي أو معنوي جداً على كل الصفات المدروسة في كلا الموسمين والتفاعل بينهما عدا صفة عدد الأيام حتى النضج في الموسم الثاني وصفتي ارتفاع النبات ووزن الألف حبة في كلا الموسمين. كان لأصناف القمح تأثير معنوي أو معنوي جداً على كل الصفات المدروسة في كلا الموسمين والتفاعل بينهما عدا صفة وزن الألف حبة في الموسم الثاني. كان تأثير التفاعل من الدرجة الأولى معنوي أو معنوي جداً في أغلب الحالات. كانت طريقة الزراعة على مصاطب هي أفضل طريقة والتي أعطت أعلى محصول حبوب بمتوسط ٨,٩١ طن للهكتار، داخل طريقة الزراعة على مصاطب كان الصنف سخا ٩٥ هو أفضل صنف حيث أعطى أعلى محصول حبوب بمتوسط قدره ٩,٥٨ طن للهكتار.