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DETERMINATION OF OPTIMUM SEEDING RATE FOR SOME BREAD WHEAT CULTIVARS

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ABSTRACT

A field experiment was carried out during 2015/2016 and 2016/2017 growing seasons at Sakha Agric. Res. Station, Kafer El-Sheikh, Egypt, to evaluate six bread wheat cultivars, i.e. Sids12, Giza 171, Gemmeiza11, Misr3, Shandaweel1 and Sakha 95 differed in their seed size and 1000-kernel weight under eight seeding rates (100,150, 200, 250,300,350, 400 and 450 grain m^{-2}) using a split plot design in a randomized complete block arrangement with three replications. The wheat cultivars distributed in the main plots and seeding rates in sub-plots. The results indicated that wheat cultivar Sids12 recorded the lowest values for days to heading, anthesis, maturity, plant height and straw yield. On the other hand, Giza 171 and Shandaweel1 were the latest for earliness characters comparing with the other wheat cultivars. The cultivar Sakha 95 was the highest in grain filling rate, plant height, number of spikes per m^{-2}, straw yield and grain yield. The two cultivars, Gemmeiza11 and Giza 171 recorded the highest values for 1000 kernel weight and spike length. Seeding rates significantly influenced all the studied characters. Lower seeding rates increased most earliness characters, 1000-kernel weight and number of kernels spike^{-1}. Increasing seeding rate increased plant height, number of spikes m^{-2}, straw yield and grain yield. Grain yield was significantly affected by the interaction between cultivars and seeding rates in both growing seasons. The quadratic model was the best among the response models tested for describing response of grain yield of the six wheat cultivars to seeding rates in both seasons. The optimum seeding rate was ranged from 46.62 to 83.10 kg fed^{-1} and from 46.90 to 77.27 kg fed^{-1} and optimum grain yield was ranged from 20.53 to 26.31 ard fed^{-1} and from 21.07 to 27.00 ard fed^{-1} with profit ranged from (11680.62 to 15333.53 LE fed^{-1}) and (1 2049.34.20 15777.31 LE fed^{-1}) in the first and second season, respectively. The optimum seeding rates across the two seasons for the six wheat cultivars Sids12, Giza 171, Gemmeiza11, Misr3, Shandaweel1 and Sakha 95 were 73.22, 71.27, 80.19, 59.19, 46.76 and 56.66 kg fed.$^{-1}$, respectively. This study, indicated that 1000-kernel weight must be taken in consideration, when determining the recommended seeding rates of the wheat cultivars. Therefore, cultivars with large and heavy kernel weight needs a higher seeding rate than those of small size.

Key words: ***Wheat, Yield, Kernels size, Quadratic model, Response curve, Economic analysis.***

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a major cereal crop in many parts of the world and it is commonly known as the king of cereals. It is the staple food for a large part of world population including Egypt. The annual wheat cultivated area in Egypt was around 3 million feddan which producing about 9 million tons. Increasing wheat productivity is a national target in Egypt to fill the gap between wheat consumption and production. In Egypt, these is still a gap between farmers' and research fields production due to lack of awareness among farmers about the use of the proper agronomic managements involving cultivars, sowing date, timing of irrigation, fertilizers and seeding rate … etc.

The proper wheat cultivar plays a very important role in determining grain yield of wheat. The wheat Research Department produced many high-yielding and rusts resistance wheat cultivars. These cultivars are different in their yield potential due to the differences tillering. Besides, it differs in their seed size (large - medium and small). The difference in the weight of a thousand grains and therefore in the number of grains, may indicate the difference in the amount of seed needed for cultivation.

Seeding rate along with varying seed size are the most important agronomic factors which significantly influence the grain yield of wheat (Sarker *et al* 2009). Higher wheat grain yield with better quality requires appropriate seeding rates for the grown cultivars. However, the increasing seeding rates above optimum level may increase the production cost without any increase in grain yield (Rafique *et al* 2010).

The technical recommendation of Wheat Research Department recommended the use of a seeding rate of 60 kg $fed.^{-1}$ for all wheat cultivars. However, many farmers use very higher seed rates than recommended, sometimes even double of the seeding rates. Higher plant density resulting in shorter spike length, lower number of grains $spikes^{-2}$. In addition, dense planting does not always increase yield production, because seeding rates also influence inter-plant competition (Park *et al* 2003).

EL Hag (2016) used four deferent seeding rates (200, 250, 300 and 350 seeds m^{-2}) and two bread wheat cultivars (Misr1 and Sids 12). Data indicated that the lower seeding rates increased number of days to heading and maturity,1000-kernel weight, number of kernels $spike^{-1}$ and harvest index. Increasing of seeding rates increased plant height, number of spikes m^{-2}, grain and straw yields with nonsignificant difference between 300 and 350 seed m^{-2}. Julio Isidro *et al* (2017) indicated that increasing seeding rates up to 380 seeds m^{-2} increased grain yield. The optimum seeding rates for cultivars grown at Swift Current and Regina were 272 to 326 seeds m^{-2} and 217 to 272 seeds m^{-2}. Kilic and Gursoy (2010), tested six seeding rates (50, 150, 250, 350, 450 and 550 seed per m^{-2}). They found that seeding rate affected both grain yield and its components. The results revealed that 250 seed per m^{-2} (111 kg ha^{-1}) proved to be the optimum seeding rate that produced the highest grain yield (5162 kg ha^{-1}) as an average across all years.

El-Hendawy (2016) found that the seeding rates of 350 and 250 seeds m^{-2} were the most effective to obtain the lowest value for seasonal yield response factors under 0.75 and 0.50 seasonal crop evapotranspiration (ET), respectively. Based on the production functions of grain yield versus seeding rates for each irrigation rate, the optimum seeding rate for the maximum grain yield was 411 and 425 seeds m^{-2} for 1.00 ET, 362 and 378 seeds m^{-2} for 0.75 ET and 315 and 350 seeds m^{-2} for 0.50 ET in the first and second season, respectively.

The objective of this study was to determine the optimum seeding rate for new bread wheat cultivars different in seed size and weight to determine their optimum yields. The techniques utilized include fitting polynomial curves and performing economic analysis of the response curve.

MATERIALS AND METHODS

A two years' study was conducted at Sakha Agricultural Research Station, Kafr El-Sheikh, Agricultural Research Center (ARC), Egypt, during 2015/2016 and 2016/2017 growing seasons to study the response of some commercial bread wheat cultivars to different seeding rates. The experimental design was laid out using a split plot design a randomized complete block arrangement in three replications. Six bread wheat cultivars *i.e.* Sids12, Giza 171, Gemmeiza11, Misr 3, Shandaweel1 and Sakha 95 (Table 1) were allocated to the main plot and eight seeding rates of (100, 150, 200, 250, 300, 350, 400 and 450 grains m^{-2}) in the sub plots. The soil at the experimental site was clay and p^H of 7.8 and 8.2 in 1st and 2nd seasons, respectively. The meteorological data were recorded for the two winter growing seasons from Sakha meteorological station (Table 2). Sowing was performed on November, 25and November, 28 in 1st and 2nd seasons, respectively. In the two growing seasons, the experimental plot area was 4.8 m^2. Each plot consisted of six rows, 4 m long and 0.2 m apart. The previous crop was maize in both seasons. At seed bed preparation 15.5 kg P_2O_5 fed^{-1} was applied. Nitrogen fertilizer was added in the form of urea (46.5% N) at a rate of 75 kg N fed^{-1} splited to three equal doses at seeding, before the first and the second irrigations. All other cultural practices were applied as recommended for wheat production in North Delta Region.

Table 1. Name and pedigree of the six studied bread wheat cultivars.

Cultivar	Cross Name/ Pedigree
Sids 12	BUC//7C/ALD/5/MAYA74/ON//1160.147/3/BB/GLL/4/CHAT"S"/6/ MAYA/VUL//CMH74A.630/4*SX SD7096-4SD-1SD-1SD-0SD
Giza 171	SAKHA 93/GEMMEIZA 9 S.6-1GZ-4GZ-1GZ-2GZ-0S
Gemmeiza 11	BOW"S"/KVZ"S"//7C/SER182/3 /GIZA168/SAKHA 61 GM7892-2GM-1GM-2GM-1GM-0GM
Shandweel1	SITE/MO/4/NAC/TH.AC//3*PVN/3/MIRLO/BUC CMSS93B00567S-72Y-010M-010Y-010M-3Y-0M-0HTY-0SH
Misr 3	ATTILA*2/PBW65*2/KACHU CMSS06Y00582T-099TOPM-099Y-099ZTM-099Y-099M-10WGY-0B-0EGY
Sakha 95	PASTOR // SITE / MO /3/ CHEN / AEGILOPS SQUARROSA (TAUS) // BCN /4/ WBLL1. CMA01Y00158S-040POY-040M-030ZTM-040SY-26M-0Y-0SY-0S.

Table 2. Monthly mean of air temperatures (AT C), relative humidity (RH%) and rainfall (mm/month) in winter seasons of 2014/2015 and 2015/2016 at Sakha location.

Month	Temperature				RH%		Rainfall (mm)	
	Max.	Min.	Max.	Min.	2014/15	2015/16	2014/15	2015/16
Nov.	24.30	13.79	24.75	14.42	74.15	75.62	24.60	12.15
Dec.	22.27	9.72	20.36	8.33	76.05	78.27	5.70	25.00
Jan.	18.70	6.46	18.40	6.30	74.60	74.10	52.55	42.70
Feb.	19.01	7.65	23.53	6.70	74.75	70.00	38.80	-
Mar.	22.69	11.69	23.67	11.61	70.59	69.76	6.25	13.20
Apr.	27.64	13.70	30.03	14.22	63.40	61.72	23.90	-
May.	30.19	18.79	31.15	19.0	61.70	58.33	-	-

Max = maximum temperature, Min = minimum temperature.

Data was recorded included, earliness characters, *i.e.* days to heading (DTH), days to anthesis (DAN), days to maturity (DTM), grain filling period (GFP, the number of days from anthesis to maturity) and grain filling rate (GFR, kg fed^{-1} $days^{-1}$ and equal to GY kg divided by GFP), At harvest, data on grain yield and its attributes were recorded as follows: plant height (PLH) in cm, number of spikes per square meter, m^{-2} (NSM^{-2}), 1000-kernel weight (TKW, g), number of kernels $spike^{-1}$ (NKS^{-1}), spike length (SL) in cm, grain yield (GY, ardb fed^{-1} , ardab =150 kg and one Feddan= 4200 m^2), straw yield (SY) in ton fed^{-1} and harvest index (HI).

Statistical analysis

A single analysis of variance was separately done for the data of each season according to Snedecor and Cochran (1994). Treatment means were compared using the least significant difference test (L.S.D.) at 0.05 level of significance according to Steel et al (1997).

Response curve analysis

To determine the optimum seeding rate directly or indirectly some types of models were filled to the collected data when several seeding rates are applied. The best models were used to respond the grain yield ardab fed^{-1} for the six cultivars to the tested seeding rates during the first and second seasons, according to Neter *et al* (1990). The tested models were linear, quadratic and logarithmic.

(1): The linear model is defined by the equation; $\mathbf{Y = \mathit{a} + \mathit{b}\ (SR)}$

(2): The quadratic model is defined by the equation; $Y = \mathbf{\mathit{a} + \mathit{b}\ (SR) + \mathit{c}\ (SR)^2}$

(3): The logarithmic model is defined by the equation; $\mathbf{Y = \mathit{a} + \mathit{b}\ In\ (SR)}$

Where, Y represents grain yield, (SR) is the applied seeding rate, (a) is the intercept, b and c are coefficients of the regression equation. Coefficient of determination (R^2), standard error (SE) and significance of the model was used to compare the above-mentioned response models. The model that had the highest (R^2) value and the lowest estimate (SE) was the best model for describing the relationship between grain yields and seeding rate (SR).

Economic analysis

The economic techniques used to determine the optimum seeding rates depend on the model used to fit the data. Economic and optimum seeding rate also depends directly on the price of seeds and selling price of the final grain yield (ardab fed^{-1}).

For the data obtained from each year, the optimal rate could be obtained by optimizing the total profit equation (Engelstad 1985, and Dillon and Anderson 1990). In this case, since we are fixing the levels of all other factors throughout all our experimental plots, then the total profit equation represents returns for those fixed factors. Calculus techniques are then used to maximize the total profit.

The total profit equation is: $\pi = P_y\, f(x) - P_x \mathbf{x}$

Where: π is the amount of profit, P_y is the price of the product (grain yield ardab fed^{-1}), P_x is the price of input (in this case seeding rate), X is the level of input (in this case seeding rate) and f (x) is the production function. By taking the first derivative of the above profit equation with respect to X and equating that to zero:

$$\frac{\sigma\pi}{\sigma_x} = P_y \;\; \sigma \frac{f(x)}{\sigma x} - P_x = 0$$

Which can be written as:

$$P_y \;\; \sigma f(x) \sigma_x \; = P_x$$

This gives the first order condition on profit maximization which says that the marginal value of the product should equal the grain of seeding rate price at the optimum. Solving this first order condition for the level of X (the only unknown) gives the optimum seeding rate. In other words, the farmer would continue increasing seeding rates until the returns from the last unit added is just equal to that unit's price. The price of wheat grains used for the economic analysis were those prevailing in Egypt during both seasons of 2015/2016 and 2016/2017 *i.e*. LE 7.67/kg for the price of sowing seeds LE 600 ardab for commercial wheat grains.

RESULTS AND DISCUSSION

1. Earliness characters and Plant height

Results in Table (3) showed a significant difference among the wheat cultivars, seeding rates and the interactions for all earliness characters and plant height in the two growing seasons. The interactions between wheat genotypes and seeding rates were insignificant except for grain filling rate in the first season only. EL Hag (2016) indicated that, the interaction between two bread wheat genotypes and seeding rates were insignificant for days to heading, maturity, grain filling rate, grain filling period and plant height.

Table 3. Mean performance of earliness characters and plant height for wheat cultivars evaluated under eight seeding rates in 2015/2016 and 2016/2017 seasons and their interaction.

Wheat cultivar (C)	Days to heading (day)		Days to anthesis (day)		Days to maturity (day)		Grain filling period (day)		Grain filling rate (kg fed^{-1}day^{-1})		Plant height (cm)	
	2015/016	2016/017	2015/016	2016/017	2015/016	2016/017	2015/016	2016/017	2015/016	2016/017	2015/016	2016/017
Sids 12	90.29	96.04	100.79	106.08	143.79	146.96	43.00	40.88	63.80	70.74	103.33	107.3
Giza 171	95.58	102.83	105.83	112.46	147.46	153.42	41.63	40.96	79.20	73.86	111.46	115.25
Gemmeiza 11	93.88	98.54	104.71	108.13	144.75	148.54	40.04	40.42	67.09	72.77	109.79	113.35
Misr 3	94.63	100.71	103.63	110.00	145.67	151.25	42.04	41.25	82.00	86.47	105.21	108.75
Shandaweel 1	95.67	102.38	105.54	112.79	147.21	152.71	41.67	39.92	81.98	81.43	110.21	113.35
Sakha 95	94.83	101.71	102.79	111.08	144.08	147.79	41.29	36.71	89.73	102.85	112.29	116.75
F -Test	**	**	**	**	**	**	**	**	**	**	**	**
LSD 0.05	1.09	1.02	1.49	0.90	1.93	0.86	0.99	0.99	6.68	4.00	2.64	3.25
Seeding rate (SR) (number of grains m^{-2})												
100	95.94	102.39	106.28	112.06	148.94	152.39	42.67	40.33	58.01	64.46	101.11	105.00
150	95.50	101.78	105.72	111.72	148.11	151.89	42.39	40.17	65.80	73.26	102.78	106.67
200	94.78	101.11	104.89	111.11	146.33	150.83	41.44	39.72	77.85	78.02	105.56	108.61
250	94.17	100.44	103.83	110.22	145.39	150.44	41.56	40.22	80.65	81.64	107.50	110.83
300	93.89	99.94	103.39	109.83	144.72	150.00	41.33	40.17	81.96	84.58	109.17	113.89
350	93.61	99.83	103.17	109.33	144.33	149.44	41.17	40.11	86.14	86.24	111.39	114.44
400	93.06	99.00	102.33	108.72	143.39	148.61	41.06	39.89	87.17	90.29	114.72	119.34
450	92.22	98.44	101.44	107.72	142.72	147.28	41.28	39.56	80.81	89.83	117.50	120.89
F -Test	**	**	**	**	**	**	*	**	**	**	**	**
LSD 0.05	0.91	0.75	1.16	0.79	0.93	0.87	1.10	0.94	3.98	3.56	2.24	3.24
C X SR	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	NS	NS

1.1. Effect of wheat cultivars

Data in Table (3) indicated that, the cultivar Sids12 was the shortest in plant height and the earliest for days to heading (90.29 and 96.04 day), days to anthesis (100.79 and 106.08 day) and days to maturity (143.79 and 146.96 day) characters in the both growing seasons, respectively.

Frahat and Mohamed (2018) noted that, Sids12 was the earlier cultivar than Giza 171, Sakha 95, Shandaweel1 and Misr 3 for days to heading, anthesis and maturity. On the other hand, Giza 171 and Shandweel1 cultivars recorded the highest values for days to heading, days to anthesis and days to maturity. The cultivar Sakha 95 was superior for grain filling period in the second season and grain filling rate in both seasons, which coincide with the results of Gab Alla *et al* (2018) who indicated that, Sakha 95 had the shortest grain filling period and the highest value for grain filling rate. Pireivatlou *et al* (2011) reported that the short effective grain filling period and high grain filling rate are the major factors for producing higher grain yield in wheat. In addition, they recorded a high value for plant height in these studies. The cultivar Gemmeiza 11 recorded the lowest value for grain filling period in the first season. While the cultivar Misr 3 recorded the lowest values for grain filling period in both growing seasons. These variations among the wheat genotypes might reflect, partially, their differences in the genetic backgrounds. These results obtained herein are in agreement with those of EL Hag (2016), Akhter *et al* (2017), Darwish *et al* (2017), El-Wahsh (2017) and Frahat and Mohamed (2018).

1.2. Effect of seeding rates

The results in Table (3) showed the effect of eight seeding rates on studied traits of wheat cultivar during the two-growing season. Results showed that the lowest seeding rates (100 and 150 seed m^{-2}) recorded the highest values for most of earliness characters, while the high seeding rate (450 seed m^{-2}) recorded the lowest values for all earliness characters. In the context, EL Hag (2016) showed that increasing seeding rates decreased the number of days to heading and number of days to maturity. The previous data agree with our findings in which number of days to heading, anthesis and maturity decreased with increasing seeding rates from 100 to 450 seed m^{-2}.

The results indicated that, plant height increased with increased seeding rate. Baktash and Naes (2016), EL Hag (2016) and El-Wahsh (2017) reported that increasing wheat seeding rates positively increased the grain filling rate and plant height. In the same aspect, Ayalew *et al* (2017) reported that, increasing seed density resulted in increased plant height, due to increasing the competition for light interception between plants and drives upward vegetative growth. Thompson *et al* (1993) fond that, reducing seeding rates may be the reason for delayed maturation.

1.3. Effect of the interaction

The interactions between the studied wheat cultivars and seeding rates were significant for grain filling rate in the first season only (Table 4). The results indicated that the highest value for grain filling rate was recorded by using 350 seeds m^{-2} for Sakha 95 and the low value recorded by Sids 12 when used 150 seeds m^{-2} seeding rate. Similar results were found by EL Hag (2016).

Table 4. The interaction effect of wheat cultivars and seeding rates (SR) on grain filling rate in 2015/2016 season.

Factor	Sids 12	Giza 171	Gemmeiza11	Misr3	Shandaweel1	Sakha95
SR1 (100)	45.20	53.70	50.50	61.87	67.77	69.04
SR2 (150)	43.65	73.03	45.95	76.12	70.42	85.65
SR3 (200)	72.53	73.60	71.37	81.90	80.48	87.24
SR4 (250)	64.00	83.66	68.98	83.68	86.51	97.05
SR5 (300)	65.08	85.99	70.13	89.16	90.16	91.25
SR6 (350)	73.14	84.78	73.57	93.91	91.34	100.11
SR7 (400)	75.12	92.53	81.55	87.03	92.50	94.28
SR8 (450)	71.70	86.27	74.70	82.32	76.69	93.20
$LSD_{0.05}$	9.67					

2. Yield components

Table (5) showed a significant difference among the wheat cultivars and the eight seeding rates for all yield components characters, number of spikes m^{-2}, 1000-kernel weight, number of kernels per spike and spike length in the two growing seasons. However, the interaction between the wheat cultivars and seeding rates were insignificant for all yield components characters.

Table 5. Mean performance of number of spikes, 1000-kernel weight, number of kernels spike^{-1} and spike length as affected by bread wheat cultivars, seeding rates and their interaction in 2015/16 and 2016/17 growing seasons.

Cultivar (C)	Number of spikes m^{-2}		1000-kernel weight		Number of kernels spike^{-1}		Spike length (cm)	
	2015/016	2016/017	2015/016	2016/017	2015/016	2016/017	2015/016	2016/017
Sids 12	310.32	347.18	46.98	44.07	70.43	73.82	14.83	13.53
Giza 171	366.96	358.89	48.93	45.77	66.59	70.57	14.90	13.52
Gemmeiza 11	298.25	336.32	49.49	46.55	65.01	72.01	15.01	14.64
Misr 3	348.04	362.69	43.84	42.69	59.42	65.98	12.69	12.37
Shandaweel 1	352.60	353.84	36.26	34.68	60.55	65.27	12.86	13.55
Sakha 95	368.42	387.41	42.19	42.68	68.38	63.29	12.65	13.19
F -Test	**	**	**	**	*	**	**	**
LSD 0.05	34.63	36.95	1.70	1.38	6.76	5.55	0.63	0.65
Seeding Rate (SR) (number of grains m^{-2})								
100	230.49	242.98	48.56	45.85	72.18	79.24	15.22	14.56
150	271.78	295.47	46.83	44.88	70.77	76.72	14.61	14.22
200	309.45	331.84	45.83	44.17	67.80	72.27	14.41	13.92
250	340.46	361.03	44.62	43.18	67.10	69.89	13.99	13.47
300	356.67	373.79	44.34	42.25	62.96	67.11	13.78	13.27
350	384.51	396.45	43.07	41.27	61.22	64.66	13.31	13.14
400	410.11	422.23	42.62	40.48	60.65	61.24	12.88	12.95
450	422.64	437.97	41.03	39.37	57.83	56.79	12.38	12.2
F -Test	**	**	**	**	**	**	**	**
LSD 0.05	26.97	26.1	1.43	1.97	4.47	3.84	0.69	0.62
C x SR	NS	NS	NS	NS	NS	NS	NS	NS

2.1. Effect of wheat cultivars

Number of spikes m^{-2} seems to be the most important character toward the wheat crop. The economic yield of most cereals is determined by their productive number of tillers the plant produces (Ayalew *et al* 2017). Generally, Sakha 95 gave the higher number of spikes (368.42 and 387.41) in the two-growing seasons followed by Giza 171, Sandaweel1 and Misr 3, whereas, the cultivars Gemmeiza11 and Sids12 gave the lowest values in both seasons. Concerning 1000 kernel weight, the two cultivars Gemmeiza11 and Giza 171 produced significantly the heaviest values in both growing seasons. The cultivar Shandaweel1 recorded the lowest 1000-kernel weight in both growing seasons. The difference in thousand kernel weight among the wheat cultivars were attributed to their variable essential potential. The highest number of kernels spike^{-1} (70.43 and 73.82) were produced by the wheat cultivar Sids12 in 2015/2016 and 2016/2017 growing season, respectively.

2.2. Effect of seeding rates

In wheat, yield is mainly determined by number of spikes m^{-2} ,1000-kernel weight and number of kernels per spike. The current experiment showed that different seeding rates revealed a significant difference in number of spikes among all treatments, the maximum number of spikes m^{-2} of 422.64 and 437.97 were obtained by using 450 seeding rate m^{-2} in both growing seasons followed by seeding rate of 400 seeds^{-2}. While, the minimum number of spikes m^{-2} were obtained with the lowest 100 seeding rate m^{-2} which produced 230.49 and 242.98, spikes m^{-2}, respectively (Table 5). Generally, the low seeding rate of 100-grain m^{-2} produced the highest values of 1000 kernel weight (48.56 and 45.85 g), number of kernels per spike (72.18 and 79.24) and spike length (15.22 and 14.56 cm), in both growing seasons, respectively. EL Hag (2016) indicated that, increasing seeding rate increased steadily number of spikes and decreases 1000-kernel weight and number of kernels spike^{-1}. On the other hand, the high value of seeding rate (450 grain m^{-2}) recorded the lowest values for1000 kernel weight, number of kernels per spike and spike length. EL Hag (2016) added that, the decreases in 1000-kernel weight and number of kernels spike^{-1} were due to the competition on nutrients, moisture, air and light. These results are in full agreement with Kilic and Gursoy (2010), El-Hendawy (2016) and Akhter *et al* (2017).

3. Yield.

The analysis of variance showed that grain yield, straw yield and harvest index were significantly affected by wheat cultivars, seeding rate and wheat cultivars X seeding rate interaction only for grain yield in the two-growing seasons (Table 6).

3.1. Effect of wheat cultivars

The results presented in Table (6) indicated a significant difference among the six-bread wheat cultivars for grain yield, straw yield and harvest index. The variations among the genotypes might reflect, partially, difference in their genetic backgrounds.

Table 6. Mean performance of grain yield, straw yield and harvest index as affected by wheat cultivars, seeding rates and their interaction in 2015/16 and 2016/17 growing seasons.

Cultivar (C)	Grain yield (ard fed^{-1})		Straw yield (t fed^{-1})		Harvest index%	
	2015/016	2016/017	2015/016	2016/017	2015/016	2016/017
Sids 12	18.23	19.32	3.96	3.64	41.50	45.26
Giza 171	21.91	20.16	5.00	5.05	39.77	37.63
Gemmeiza11	17.89	19.60	4.22	4.62	39.10	39.22
Misr 3	22.94	23.78	4.49	4.67	43.68	43.53
Shandaweel1	22.74	21.63	5.13	4.89	40.00	40.21
Sakha 95	24.64	25.17	5.25	5.65	41.57	40.21
F -Test	**	**	**	*	**	NS
LSD 0.05	1.58	1.26	0.41	0.96	2.03	-
Seeding Rate (SR) (number of grains m^{-2})						
100	16.49	17.71	3.61	4.34	41.19	38.79
150	18.62	19.96	3.98	4.52	41.01	40.14
200	21.51	20.83	4.33	4.46	43.06	41.60
250	22.32	22.21	4.64	4.75	42.16	41.85
300	22.54	22.81	4.85	4.73	41.12	42.27
350	23.62	23.46	5.06	4.85	41.18	42.71
400	23.80	23.82	5.40	4.91	40.07	42.63
450	22.23	22.07	5.54	5.46	37.74	38.07
F -Test	**	**	**	**	**	**
LSD 0.05	1.14	0.80	0.40	0.49	2.49	2.60
C X SR	*	*	NS	NS	NS	NS

Generally, the wheat cultivar, Sakha 95 yielded (24.64 and 25.17 ardab fed^{-1}) and (5.25 and 5.65 ton fed^{-1}) for grain and straw yield in the two growing seasons, respectively. In this work, insignificant differences were found among cultivars Sakha 95, shandweel1 and Giza 171 for straw yield. The highest grain yields for Sakha 95 may be attributed to the highest number of spikes per m^{-2}. The cultivar Sids12 recorded the lowest values for straw and grain yields in both seasons. While, Misr 3 gave the highest value for harvest index in the first season. These findings agree with the findings of many researchers among whom, EL Hag (2016), Akhter *et al* (2017) and Chhokar *et al* (2018).

3.2. Effect of seeding rates

The results showed a significant variation in four traits in response to the different seeding rates. Generally, increasing seeding rates from 100 to 400 seeds m^{-2} increased grain yield from 16.49 to 23.80 and 17.71 to 23.82 ardab fed^{-1} in the first and second seasons, respectively. However, increasing seeding rates from 400 to 450 seed m^{-2} decreased grain yield. Straw yield important factor for farmers, increasing seeding rates increasing straw yield. Seeding rate 450 grain m^{-2} recorded the highest values (5.54 and 5.46 ton fed^{-1}) [1] in both seasons, respectively. However, using the highest seeding rate led to the lowest harvest index. The highest value for harvest index was recorded at the seeding rate of 200 and 400 seed m^{-2} in both seasons. The obtained results are in a good agreement with those previously reported by El-Hendawy (2016), EL Hag (2016), Akhter *et al* (2017) and Chhokar *et al* (2018).

3.3. Effect of interaction

Data in Table (7) showed that the interactions between seeding rates and wheat cultivars had significant effect on grain yield. Mean performance showed significant variation with the different seeding rates. In both seasons, data revealed that the lowest grain yield was achieved primary by the cultivars Gemmeiza11 and Sids12 at low seeding rate of 100 and 150 (grains m^{-2}) and Giza 171 at seeding rate of 100 grains m^{-2}. On the other hand, the cultivar Sakha 95 recorded the highest values for grain yield (27.11 ardb fed^{-1}) when seeding rates of 350 seed m^{-2} in the first season and 300 seeds m^{-2} (28.14 ardb fed^{-1}) in the second season.

Table 7. Effect of the interactions between cultivars and seeding rates on wheat grain yield under 2015/2016 and 2016/2017 seasons.

Season 2015/2016						
Treatment	**Sids 12**	**Giza 171**	**Gemmeiza11**	**Misr3**	**Shandaweel1**	**Sakha 95**
SR1 (100)	**13.45**	**15.26**	**13.58**	**17.41**	**19.11**	**20.11**
SR2 (150)	**12.73**	**20.74**	**12.40**	**21.68**	**20.19**	**24.00**
SR3 (200)	**19.55**	**21.10**	**18.40**	**23.28**	**22.93**	**23.82**
SR4 (250)	**18.56**	**22.87**	**18.54**	**23.78**	**23.87**	**26.31**
SR5 (300)	**18.83**	**23.46**	**18.83**	**24.49**	**24.67**	**24.93**
SR6 (350)	**21.01**	**22.96**	**19.80**	**25.87**	**24.94**	**27.11**
SR7 (400)	**21.33**	**25.31**	**21.79**	**23.96**	**25.08**	**25.33**
SR8 (450)	**20.33**	**23.57**	**19.81**	**23.1**	**21.1**	**25.49**
LSD $_{.05}$	**2.79**					
Season 2016/2017						
Treatment	**Sids 12**	**Giza 171**	**Gemmeiza11**	**Misr 3**	**Shandaweel1**	**Sakha 95**
SR1 (100)	**14.29**	**15.67**	**16.38**	**20.57**	**17.96**	**21.42**
SR2 (150)	**17.47**	**16.77**	**18.70**	**22.68**	**20.43**	**23.72**
SR3 (200)	**18.54**	**18.29**	**19.00**	**23.78**	**21.18**	**24.21**
SR4 (250)	**19.52**	**22.60**	**19.03**	**23.77**	**22.30**	**26.07**
SR5 (300)	**19.97**	**21.54**	**20.23**	**24.41**	**22.57**	**28.14**
SR6 (350)	**21.07**	**21.89**	**20.93**	**25.81**	**24.07**	**27.02**
SR7 (400)	**23.47**	**23.23**	**22.04**	**25.1**	**23.18**	**25.91**
SR8 (450)	**20.23**	**21.31**	**20.47**	**24.17**	**21.37**	**24.88**
LSD $_{.05}$	**1.96**					

Also, data in Table (7) indicated a nonsignificant difference for grain yield among seeding rate of 250, 300, 350, 400 and 450 for grain yield of

Sakha 95. Generally, in the first season, the cultivars Sakha 95, Misr 3 and Shandaweel1 did not show any significant difference's for grain yield when using seeding rate until 250 seed m^{-2}. On other hand, the results also, indicated that, the wheat cultivars Sids 12, Gemmeiza 11 and Giza 171 recorded the highest yield in both growing seasons when 400 seed m^{-2} were used. These findings are similar to those obtained by Ashmawy and Abo-Warda (2002) and EL Hag (2016).

4. Analysis of seeding rate response curve

Linear, quadratic and Logarithmic models were fitted to the data of grain yield/fed for the tested wheat cultivars in the both growing seasons. Three bases were considered to compare among the three models i.e. coefficient of determination (R^2), standard error of estimate (SE) and the significance of the model. The significant model which had the highest R^2 and lowest SE was the best model fitted to the yield data. Data in Table (8 & 9) shows the coefficient of determination (R^2), the standard error of estimate (SE) and the significance value of the three models to study the response of wheat yield to sowing rate in both seasons. The results indicate clearly that the highest value of the coefficient of determination (R^2) was in favor of the significant quadratic model for the six tested cultivars in both seasons in addition to its lower SE indicating that the quadratic model is the best model compared to others. So, the regression equations (quadratic model) which is considered the best of the response seeding rate in the both seasons.

5. Economic analysis

The results of the economic analysis for the first and second seasons of seeding rates presented in Table (10), the maximum, recommended and optimum sowing rate estimated by the quadratic equation. The maximum seeding rate were (78.75, 76.32, 86.55, 59.78, 47.56 and 60.54 kg/fed) in the first season, while in the second season the maximum sowing rates were (72.93, 71.32, 82.00, 63.47, 48.36 and 57.00 kg/fed) for the six cultivars (Sids 12, Giza 171, Gemmeiza 11, Misr 3, Shandaweel1 and Sakha 95) Table (9) and Fig (1-12). Grain yield at maximum seeding rates for the studied cultivars i.e. Sids12, Giza 171, Gemmeiza11, Misr3, Shandaweel1 and sakha95 were varied from(20.85, 24.33, 20.55, 25.16, 24.80 and 26.15 ardab/fed) and (21.49, 22.42, 21.08, 25.08, 23.23 and 27.01 ardab/fed) in the first and second growing season, respectively.

Table 8. Coefficient of determination (R^2), standard error of estimate (SE) and significant value for linear, quadratic, and Logarithmic models for grain yield of wheat cultivars in both seasons.

Cultivars model	Sids12			Giza 171			Gemmeiza11			Misr3			Shandaweel1			Sakha 95		
	R^2 %	SE	Sig.	R^2 %	SE	Sig.	R^2 %	SE	Sig.	R^2 %	SE	Sig.	R^2 %	SE	Sig.	R^2 %	SE	Sig.
2015/2016																		
Linear	70.9	1.933	0.009	69.6	1.814	0.010	73.8	1.782	0.006	47.1	1.992	0.060	32.3	2.064	0.142	52.2	1.591	0.043
Quadratic	82.1	1.660	0.014	89.0	1.318	0.004	83.0	1.572	0.012	94.0	0.732	0.001	88.2	0.942	0.005	82.9	1.043	0.012
Logarithmic	78.7	1.653	0.003	84.0	1.197	0.001	80.0	1.559	0.003	66.7	1.582	0.013	48.1	1.806	0.056	68.5	1.291	0.011
2016/2017																		
Linear	74.1	1.482	0.006	69.7	1.693	0.010	78.6	0.861	0.003	64.4	1.032	0.017	51.9	1.412	0.044	40.5	1.749	0.091
Quadratic	87.4	1.133	0.006	88.5	1.140	0.004	87.3	0.727	0.006	91.7	0.544	0.002	92.5	0.612	0.002	90.7	0.757	0.003
Logarithmic	83.9	1.168	0.001	80.4	1.363	0.003	86.0	0.695	0.001	79.5	0.783	0.003	68.8	1.137	0.011	57.3	1.479	0.030

Table 9. Equation of regression according to the quadratic model under eight sowing rates for six wheat cultivars in two growing seasons.

Regression equations (quadratic model)		
Cultivar	2015/2016	2016/2017
Seeding Rate (number of grains/m^2)		
Sids 12	Y = 6.288 + 0.07264 SR – 0.000091 SR^2	Y = 9.100 + 0.06303 SR - 0.000080 SR^2
Giza 171	Y = 9.359 + 0.08095 SR – 0.000109 SR^2	Y = 8.510 + 0.07495 SR - 0.000101 SR^2
Gemmeiza 11	Y = 6.669 + 0.06663 SR – 0.000080 SR^2	Y = 13.58 + 0.03530 SR - 0.000042 SR^2
Misr 3	Y = 10.17 + 0.09221 SR – 0.000142 SR^2	Y = 16.62 + 0.04813 SR - 0.000068 SR^2
Shandaweel 1	Y = 10.92 + 0.08869SR – 0.000142 SR^ 2	Y = 12.45 + 0.06503 SR - 0.000098 SR^2
Sakha 95	Y = 15.16 + 0.06560 SR – 0.000096 SR^2	Y = 14.59 + 0.07768 SR - 0.000121 SR^2
Seeding Rate (kg/fed)		
Sids 12	Y = 6.288 + 0.3682 SR – 0.002327 SR ^2	Y = 9.100 + 0.3405 SR - 0.002339 SR ^2
Giza 171	Y = 9.359 + 0.3939 SR – 0.002592 SR ^2	Y = 8.510 + 0.3899 SR - 0.002732 SR^2
Gemmeiza 11	Y = 6.669 + 0.3206 SR – 0.001852 SR ^2	Y = 13.58 + 0.1806 SR - 0.001086 SR ^2
Misr 3	Y = 10.17 + 0.5008 SR – 0.004182 SR ^2	Y = 16.62 + 0.2684 SR - 0.002129 SR ^2
Shandaweel 1	Y = 10.92 + 0.5824 SR – 0.006109 SR ^2	Y = 12.45 + 0.4464 SR - 0.004623 SR ^2
Sakha 95	Y= 15.16 + 0.3702 SR – 0.003070 SR ^2	Y = 14.59 + 0.4375 SR - 0.003853 SR ^2

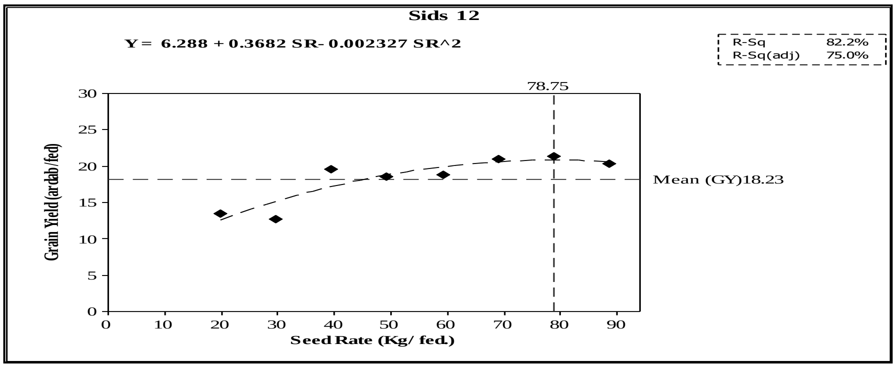

Fig. 1. Response of grain yield of wheat cultivar Sids12 to seeding rates in 2015/2016 growing season.

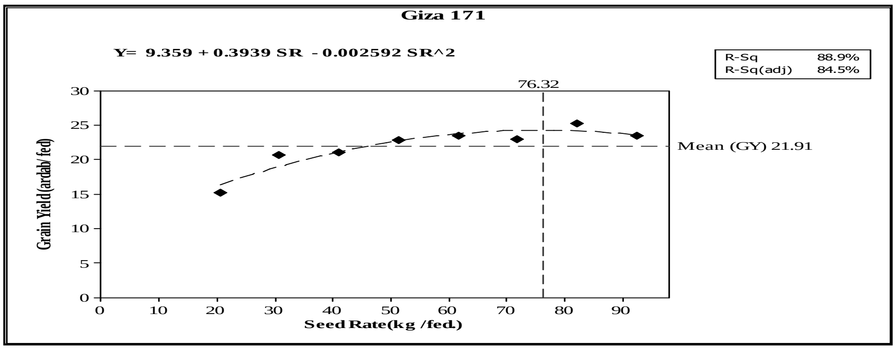

Fig. 2. Response of grain yield of wheat cultivar Giza 171 to seeding rates in 2015/2016 growing season.

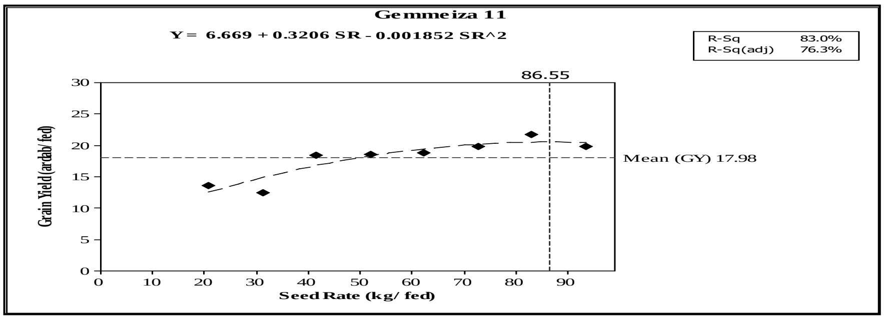

Fig. 3. Response of grain yield of wheat cultivar Gemmeiza11 to seeding rates in 2015/2016 growing season.

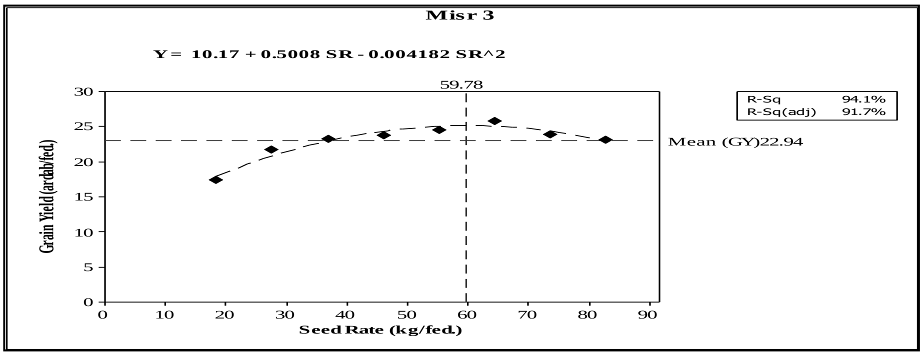

Fig. 4. Response of grain yield of wheat cultivar Misr3 to seeding rates in 2015/2016 growing season.

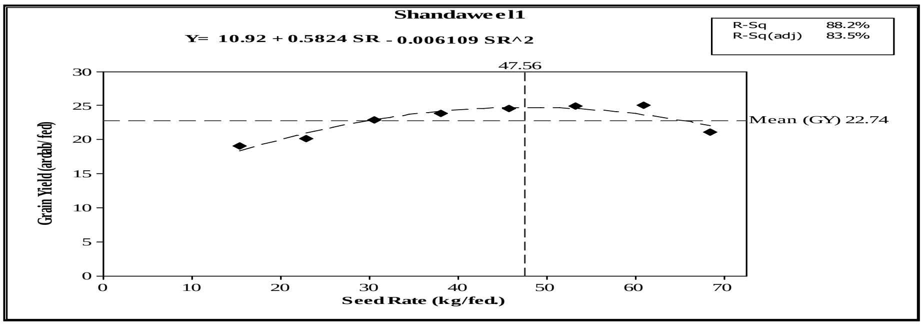

Fig. 5. Response of grain yield of wheat cultivar Shandaweel 1 to seeding rates in 2015/2016 growing season.

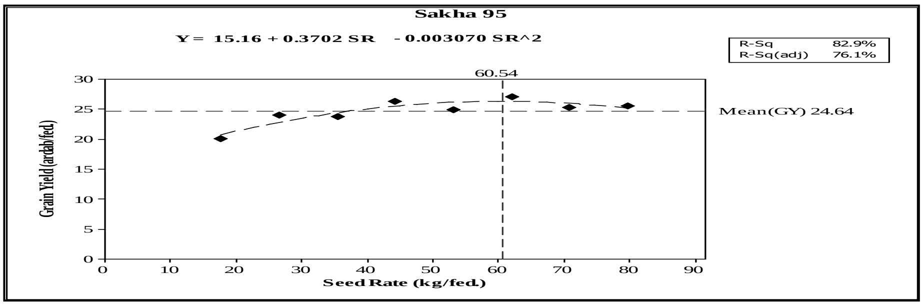

Fig. 6. Response of grain yield of wheat cultivar Sakha95 to seeding rates in 2015/2016 growing season.

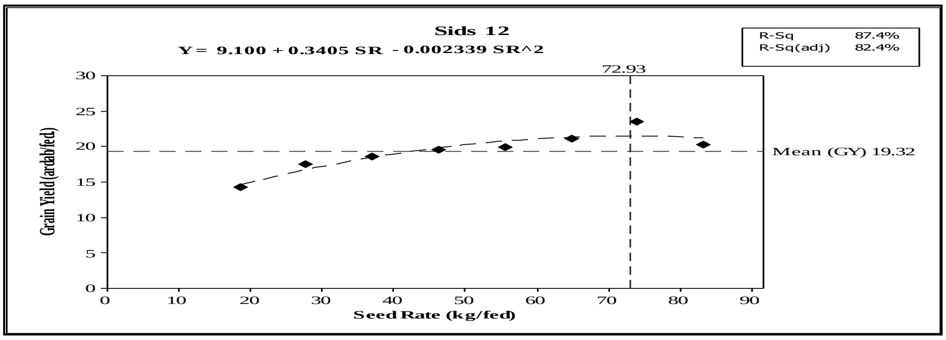

Fig. 7. Response of grain yield of wheat cultivar Sids12 to seeding rates in 2016/2017 growing season.

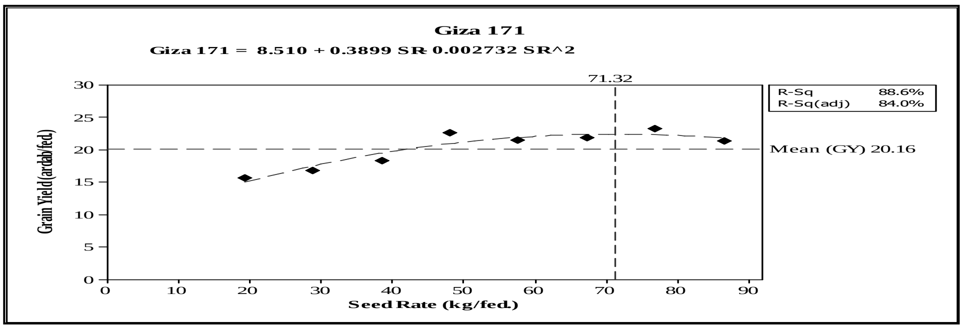

Fig. 8. Response of grain yield of wheat cultivar Giza 171 to seeding rates in 2016/2017 growing season.

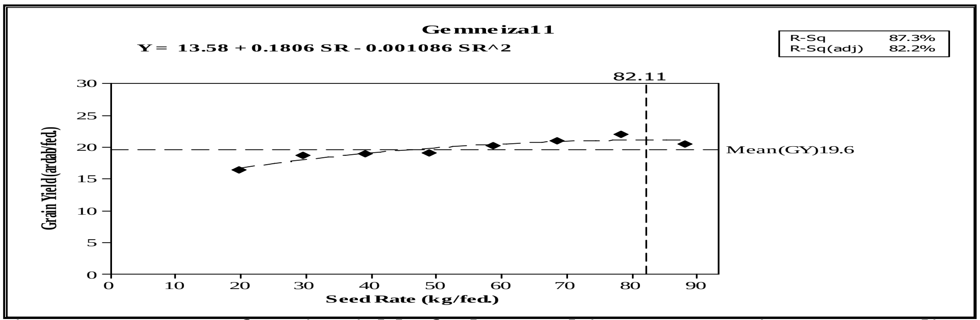

Fig. 9. Response of grain yield of wheat cultivar Gemmeiza11 to seeding rates in 2016/2017 growing season.

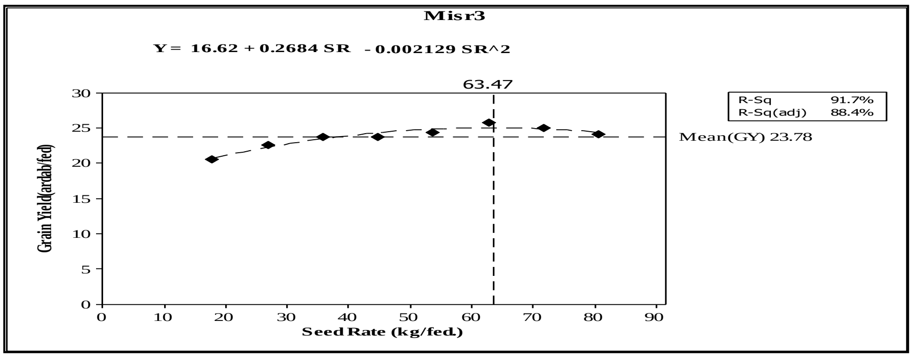

Fig. 10. Response of grain yield of wheat cultivar Misr 3 to seeding rates in 2016/2017 growing season.

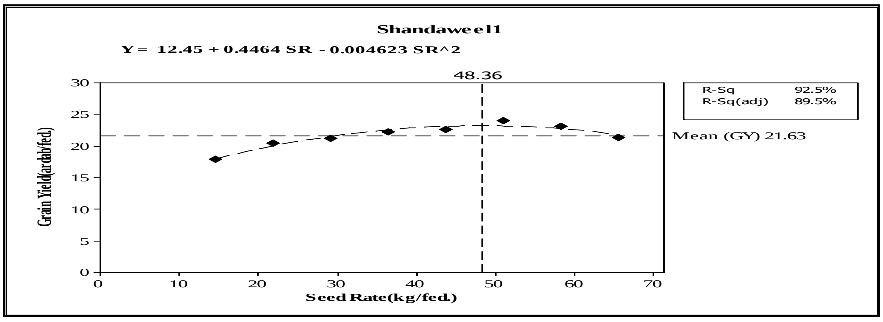

Fig. 11. Response of grain yield of wheat cultivar Shandaweel 1 to seeding rates in 2016/2017 growing season.

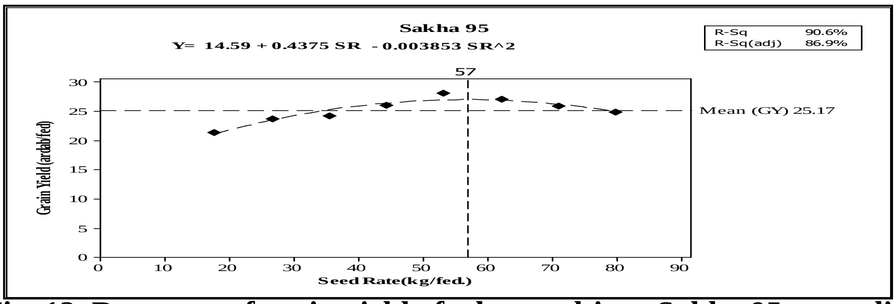

Fig. 12. Response of grain yield of wheat cultivar Sakha 95 to seeding rates in 2016/2017 growing season.

Table 10. The economic analysis of wheat grain yield under eight seeding rates (SR) for six cultivars (C) in 2016/2017 and 2017/2018 seasons.

Tested cultivars						
Cultivar	**Sids 12**	**Giza 171**	**Gemmeiza11**	**Misr 3**	**Shandaweel1**	**Sakha 95**
2015/2016						
Maximum seeding rate (kg/fed.)						
SR_{Max}(kg/fed)	**78.75**	**76.32**	**86. 55**	**59.78**	**47.56**	**60.54**
Y_{Max}	**20.85**	**24.33**	**20.55**	**25.16**	**24.80**	**26.15**
Profet Max	**11907.19**	**14010.83**	**11663.16**	**14639.29**	**14515.81**	**15225.66**
Recommended seeding rate						
Y_{Rec} (ard/fed)	**20.43**	**23.77**	**19.71**	**25.16**	**24.43**	**26.06**
$Profit_{Rec}$	**11797.80**	**13801.80**	**11365.80**	**14635.80**	**14197.80**	**15175.80**
Optimum economic seeding rate (kg/fed.)						
SR_{opt} (kg)	**76.38**	**73.52**	**83.10**	**58.35**	**46.62**	**58.21**
Y_{opt} (ard/fed)	**20.84**	**24.31**	**20.53**	**25.15**	**24.79**	**26.31**
$Profit_{opt}$	**11918.17**	**14022.10**	**11680.62**	**14642.46**	**14516.42**	**15333.53**
2016/2017						
Maximum seeding rate (kg/fed.)						
SR_{Max}	**72.93**	**71.32**	**82.00**	**63.47**	**48.36**	**57.00**
Y_{Max}	**21.49**	**22.42**	**21.08**	**25.08**	**23.23**	**27.01**
Profet Max	**12334.63**	**12904.98**	**12019.06**	**14561.19**	**13567.08**	**15768.81**
Recommended seeding rate 60 (kg/fed.)						
Y_{Rec} (ard/fed)	**21.22**	**22.18**	**20.60**	**25.08**	**22.59**	**26.97**
$Profit_{Rec}$	**12271.80**	**12847.80**	**11899.80**	**14587.80**	**13093.80**	**15721.80**
Optimum seeding rate (kg/fed)						
SR_{opt}	**70.05**	**69.02**	**77.27**	**60.03**	**46.90**	**55.11**
Y_{opt}	**21.47**	**22.42**	**21.07**	**25.08**	**23.22**	**27.00**
Profit	**12344.72**	**12922.62**	**12049.34**	**14587.57**	**13572.28**	**15777.31**
Average optimum seeding rate (kg/fed) in both growing season						
SR opt	**73.22**	**71.27**	**80.19**	**59.19**	**46.76**	**56.66**
Yopt	**21.16**	**23.37**	**20.80**	**25.12**	**24.01**	**26.66**
Profit	**12131.45**	**13472.36**	**11864.98**	**14615.02**	**14044.35**	**15555.42**

Maximum Seeding rate = $b_q/2c_q$,: SR_{opt}: optimum sowing rate = (CP - b)/2c, SR_{Max}, sowing rate price7.76 £ kg^{-1}, the yield product price= 600 £ ard^{-1} and Cp= 0.012778

The results also, showed that the cultivars Misr 3 and Sakha 95 out yielded the other cultivars in both seasons, being (25.16 and 26.15) and (25.08 and 27.01 ardab fed^{-1}) at seeding rates of (59.78 and 60.54 kg/fed) and (63.47 and 57.00 kg/fed^{-1}) in the first and the second seasons, respectively. The results showed that the cultivar Gemmeiza 11 at the highest seeding rate of (86.55 and 82.00 kg/fed gave a lower yield 20.55 and 21.08 ardab / fed) with return profit ranged from (11663.16 and 12019.06 L. E) in 2016/2017 and 2017/2018 growing seasons, respectively. On other hand, the cultivar Shandaweel1 yielded (24.80 and 23.23 ardab/ fed) and achieved a high profit of (14515.81 and 13567.08 LE / fed) with low seeding rate of (47.56 and 48.36kg/fed) in the first and second seasons, respectively.

The two cultivars Sakha 95 and Misr 3 at the recommended seeding rate (60 kg fed) recorded the highest (26.06 and 25.16) and (26.97 and 25.08 ard/fed) with highly Profit (15175.80 and 14635.80 LE / fed) and (15721.80 and 14587.80 LE / fed) in both seasons, respectively.

Meanwhile the cultivar Gemmeiza 11 recorded the lowest grain yield (19.71 and 20.60 ard/fed) with a minimum Profit value of (11365.80 and 11899.80 LE/fed) in the first and second seasons, respectively. On the other hand, the optimum seeding rate s of the cultivar Shandaweel 1 followed by the cultivar Gemmezia 11 were (46.62 to 83.10 kg/ fed) in the first season and (46.90 to 77.27 kg/fed) in the second season. The

two cultivars Gemmeiza 11and sakha 95at the optimum economic seeding rate achieved a grain yield ranged from (20.53 to 26.31 ardab/fed) and (21.07 to 27.00 ardab/fed) with Profit ranged from (11680.62 to 15333.53 LE / fed) and (12049.34 to 15777.31 LE/fed) in both seasons, respectively. The highest grain yield (25.15 and 26.30 ard/fed) achieved the maximum Profit of (14642.46 and 15333.53 LE / fed) for the two cultivars Misr 3 and Sakha 95 with the seeding rates 58.35 and 58.21 followed by the cultivar Shandaweel 1 which recorded (24.79 ard/fed and 14516.42 LE / fed at seeding rate of 46.62 kg/fed in the first season. Three cultivars namely: Sakha 95, Misr 3 and Shandaweel1, in the second growing season recorded the highest grain yield/fed and the highest profit with the optimum economic seeding rates (55.11, 60.03 and 46.90 kg/fed) with highly grain yield (27.00, 25.08 and 23.22 ard/fed) and highest profit (15777.31, 14587.57 and 13572.28 LE / fed) meanwhile, the cultivar Gemmeiza 11 yielded 21.05ard/fed when a high seeding rate 77.27 kg/fed was used and achieved a low profit of 12049.34 LE/ fed. These results are in harmony with Ashmawy and Abo- Warda (2002), Mennan and Zandstra, (2005), Soomro *et al*., (2009) and Ali *et al*., (2010).

The fact that the estimates of profitability and yield come from the response functions to seeding rates are not quite sufficient to allow for accurate comparisons between the six cultivars. For instance, information on the interaction between seeding rate and other variables is not considered when these optimal were calculated. Hence, these results should be interpreted cautiously. However, at least they give some indications about relative economic performance of the six tested wheat cultivars. A more detailed economic analysis would be required to verify these results. In fact, by comparing the highest rate of seeding rate with the recommended rate and compare those with the optimum rate found the optimal rate was found to use the lowest level of seeds and the yield was close to the recommended rate. It is worth mentioning that the optimum rate gave the highest yield. However, this increase is not economic since we obtained a similar return using the optimal seeding rate of seeds and the lowest rate of seeds. This from the economic point of view is the economic rate is to get the highest return at the lowest cost. The cultivars Misr3, Shandaweel1 and Sakha 95 recorded the highest return with the highest grain yields and the lowest level of seeding rates.

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تحديد معدل التقاوي الامثل لبعض أصناف القمح

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أجريت تجربتان حقليتان خلال موسمي الزراعة ٢٠١٦/٢٠١٥ و٢٠١٧/٢٠١٦ وذلك بهدف دراسة استجابة ستة اصناف من قمح الخبز (سدس ١٢، جيزة ١٧١، جميزة ١١، مصر ٣، شندويل ١، سخا ٩٥) مختلفة في حجم ووزن الالف حبة لمعدلات مختلفة من التقاوي ككثافة نباتية في المتر المربع وهي (١٠٠، ١٥٠، ٢٠٠، ٢٥٠، ٣٠٠، ٣٥٠، ٤٠٠ و٤٥٠ حبة/م٢) وكذلك استخدم أسلوب تحليل المنحنيات لتحديد درجة استجابة محصول الحبوب لمعدلات التقاوي المختلفة من أجل تقدير المعدل الاقتصادي الأمثل من معدلات التقاوي وتقدير العائد بالجنيه نتيجة اضافة المعدل المناسب من التقاوي لكل صنف. كان التصميم المستخدم هو القطع المنشقة مرة واحدة بتوزيع القطاعات الكاملة العشوائية في ثلاث مكررات حيث وزعت الاصناف من القمح في القطع الرئيسية في حين وزعت معدلات التقاوي في القطع الشقية. أظهرت النتائج اختلافاً معنويا بين أصناف القمح ومعدلات التقاوي تحت الدراسة لجميع الصفات المدروسة. كما وجد تفاعل بين الأصناف ومعدلات التقاوي لكل من معدل امتلاء الحبوب في العام الاول ومحصول الحبوب في كلا الموسميين تحت الدراسة. كان الصنف سدس ١٢ أبكر الاصناف لمعظم صفات التبكير حيث سجل بوجه عام اقل عدد ايام حتى طرد السنابل والتزهير والنضج وكان اقل

الاصناف طولا ومحصولا للتبن. كما سجل الصنفين جيزة ١٧١ والصنف شندويل١ أعلي القيم لصفات التبكير. تفوق الصنف سخا ٩٥ بالنسبة لصفة معدل امتلاء الحبوب وعدد السنابل في المتر المربع ومحصول الحبوب والتبن في كلا الموسمين. تأثرت جميع الصفات تحت الدراسة معنويا بمعدلات التقاوي. كان الاتجاه العام ان جميع صفات التبكير قلت قيمها مع زيادة معدل التقاوي وكذلك وزن الالف حبة وعدد حبوب السنبلة. وقد سجل أعلي محصول للحبوب عند معدل ٤٠٠ حبة/م٢ وكذلك التبن عند زيادة معدل التقاوي الي ٤٥٠ حبة/م٢ في كلا الموسمين. تأثرت صفة محصول الحبوب تحت الدراسة معنويا بالتفاعل بين الأصناف ومعدلات التقاوي حيث تفوق الصنف سخا ٩٥ وسجل أعلى محصول للحبوب عند معدل ٣٥٠ و٣٠٠ حبة/م٢ في كلا الموسمين على التوالي. أظهرت النتائج المتحصل عليها أن العلاقة بين معدلات التقاوي ومحصول الحبوب/فدان كانت تتبع منحني الدرجة الثانية في كلا الموسمين وذلك لجميع الأصناف موضع الدراسة وأعطت أعلي قيمة لمعامل التحديد (R^2) وأقل قيمة للخطأ القياسي (SE). تبين من نتائج التحليل الاقتصادي أن المعدل الاقتصادي الأمثل للتقاوي تتراوح من (٤٦,٦٢إلي٨٣,٠١) ومن (٤٦,٩٠الى ٧٧,٢٧) كجم/فدان للموسم الاول والثاني على التوالي وتراوح محصول الحبوب الناتج من إضافة المعدل الاقتصادي الأمثل للتقاوي من (٢٠,٥٣ الى ٢٦,٣١) و(٢١,٠٥ الى ٢٧,٠٠) أردب/فدان وتراوح صافي العائد من (١١٦٨٠,٦٢الى ١٥٣٣٣,٥٣) ومن (١٢٠٤٩,٣٤الى ١٥٧٧٧,٣١) جنيه/ فدان. وكان أفضل الأصناف لصافي العائد هم (مصر ٣، شندويل ١ وسخا ٩٥). من خلال تلك الدراسة نجد ان أفضل معدل للتقاوي للأصناف الستة تحت الدراسة كانت ٧٣,٢٢ كجم/ فدان للصنف سدس١٢ وللصنف جيزة ١٧١ (٧١,٢٧ كجم/ فدان) وللصنف جميزة ١١ (٨٠,١٩ كجم/فدان) وللصنف مصر ٣(٥٩,١٩ كجم/ فدان) وللصنف شندويل١(٤٦,٧٦ كجم/فدان) وللصنف سخا ٩٥ (٥٦,٦٦ كجم/فدان). يتضح من تلك النتائج ان الأصناف ذات حجم الحبوب الأكبر والأثقل تحتاج لمعدل تقاوي اعلي من التي وزن وحجم حبوبها اقل. لذلك يجب مراعاة اختلاف حجم ووزن الحبوب لضبط معدل التقاوي المناسب بالكيلوجرام لكل صنف ليطبق حقليا للحصول علي اعلي محصول حبوب.

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