Grain Yield and its Components of Rice Cultivar Sakha 106 as Affected by Sowing Date, Hill Spacing and Zinc Fertilizer Level

Khairallah A. Sh. Shebl [1] , Ali I. Nawar [1], Hossam Eldin M. Ibrahim [1] and

Abd El– Salam A. Abd El- Salam [2]

ABSTRACT

Two field experiments were conducted in the summer seasons of 2018 and 2019 at the Agricultural Research Station, Alexandria University, Egypt. The aim of the study was to investigate the effects of sowing date (May10, May 20, June 10 and June 20), hill spacing (10 x 15, 15 x 15, 25 x 15 and 30 x 15 cm) and zinc sulphate fertilizer level (0, 12, 36 and 48 kg ZnSO4/ha) on grain yield and yield components of rice cultivar Sakha 106. The design applied in the two seasons was partially replicated central composite design in which factorial and star points were replicated three times.

The results indicated that delaying sowing resulted in progressive decrease in 100- grain weight and grain yield (beyond May 10), number of effective tillers/m^2 and number of grains/panicle (beyond May 30). Hill spacing of 20 x 15cm was found to be optimal for number of grains/panicle, 100- grain weight and grain yield/ha, whereas number of tillers/ m^2 was highest at 30 x 15cm hill spacing. Zinc sulphate fertilization level of 48 kg/ha increased all yield and yield components. It could be concluded to sow cultivar Sakha 106 in the region early on May 10 at hill spacing of 20 x 15cm and application of 48 kg ZnSO$_4$/ha to obtain high grain yield potential as a result of optimal production of yield components.

Key words: Rice, sowing date, hill spacing, zinc fertilizer, grain yield.

INTRODUCTION

Rice (Oryza sativa L.) is considered as one of the most important cereal crops not only in Egypt but also all over the world, and the second largest cultivated crop area after wheat. The total cultivated area with rice in Egypt was about 0.55 million hectare in 2019. Improvement of rice production can be achieved through different agronomic practices and treatments. Sowing date, hill spacing and zinc levels are amongst the agricultural practices that affect rice growth and productivity.

Sowing date of rice crop is important because it ensures that vegetative growth occurs during a period of satisfactory temperature and high levels of solar radiation and guarantees that grain filling occurs at suitable temperatures, hence good grain quality is achieved. (Bashir et al, 2010). Early sowing of rice tends to increase grain yield (Sha and Linscombe, 2007; Pal et al., 2017) through increasing number of effective tillers/plant (Safdar et al., 2008; Mrudulha and Rao, 2020) and number of grains per panicle (Safdar et al., 2008).

Hill spacing ensures appropriate distribution of plants in the field and supply of growth requirements at a suitable level. Optimum plant spacing ensures plants to grow properly both in their above and underground parts through different utilization of solar radiation and nutrients. Increasing plant density, through decreasing hill spacing or increasing number of plants per hill, led to increase grain yield of rice (Salem 2006; Vijayalaxmi et al.,2016) by increasing number of effective tillers/m2 (Rex Immanuel et al., 2020). However, wider spacing increased number of grains/ panicle due to increase in fertility percentage and increase in grain weight (Anwari et al., 2019).

Zinc is an essential micronutrient for rice growth and productivity under submerged condition (Alam and Kumar, 2015). The role of zinc in photosynthesis and starch formation has been reported by Brown et al., (1993) and Marschner (1995). Also, zinc plays an important role in attaining membrane integrity (Welch et al., 1982). Proper fertilization management of submerged rice include the application of zinc for its enhancement of plant growth and productivity. Several researchers reported that application of adequate zinc levels increased rice grain yield (Sudha and Stalin, 2015; Ammanullah et al., 2020; Dhakad et al., 2020) through increasing yield components such as number of fertile tillers/m2 (Mafi et al., 2013) or number of grains/panicle (Mafi et al., 2013; Esfahani et al., 2014).

The main objective of the present study was to investigate the effect of sowing date, hill spacing and zinc levels on growth and productivity of Sakha 106 rice cultivar.

MATERIAL AND METHODS

The present investigation was carried out at the Agricultural Research Station, Alexandria University, during the two summer seasons of 2018 and 2019. The objective of this study was to determine the effect of sowing date, hill spacing and zinc application levels on yield and yield components of rice cultivar Sakha 106.

Sakha 106 is a japonica type cultivar developed in 2010 by crossing of Giza 177 Egyptian early variety as female parent and Hexi 30 early Korean variety as male parent. Duration of Sakha 106 is around 126 days from seed to seed. It is a short grain type with low amylose content and high milling out turn (Kandil *et al.* 2012). The nursery seedbed and permanent field were prepared by mechanical plowing, harrowing and leveling. Grains were soaked in water for two days, followed by an incubation period of 2-3 days for seed germination initiation. The permanent field experimental size unit was $2 \times 2 = 4m^2$.

Super phosphate (15.5% P2O5), at the rate of 250 kg/ha, was incorporated into the soil of nursery seedbed and permanent field during land preparation in both seasons . Nitrogen, in the form of urea (46%), was applied at the rate of 150 kg/ ha, after 5 and 25 days from transplanting in the two seasons. Meanwhile, a dose of 17 kg N/ha was applied in the nursery.

The plots were continuously kept flooded with irrigation water throughout the growing season. Weeds were chemically controlled using SHNEL 50% applied 4-7 days after transplanting. In some cases, weeds were manually controlled in nursery and permanent field.

A partially replicated central composite design (Dykstra, 1960) of three replications was used in the two seasons of study. In that design, factorial and star points were replicated to obtain an estimate of error variance instead of central points as in the rotatable central composite design. The factors and levels of each factor are presented in the following table:

Table 1. Physical and chemical properties of soil of experimental site as an average of the two seasons

Physical properties		chemical properties		Cations(meqL^{-1})		Anions(meqL^{-1})			
Sand %	43.5	EC (dsm^{-1})	1.58	Ca^{++}	3.87	CO3^{--}	1.43	SAR	4.94
Silt %	16.8	PH	8.44	Mg^{++}	3.81	HCO3$^-$	3.56	CaCO3 %	8.82
Clay %	39.5	OM %	2.47	Na$^+$	9.66	Cl$^-$	6.33	Available	
Sandy clay loam				K$^+$	0.68	SO4^{--}	6.7	Zn (ppm)	2.64

Table 2. Average maximum, average and minimum temperatures at experimental site during 2018 and 2019 seasons

Month	Season 2018			Season 2019		
	Max.	Ave.	Min.	Max.	Ave.	Min.
April	26.9	20.7	17.33	24.7	18.3	14.9
May	29.6	24.2	20.9	31.7	23.2	18.7
June	29.8	26.4	24.3	28.4	26.5	24.4
July	32.05	27.9	25.8	30.11	28.05	25.6
August	29.2	28.3	26.7	29	28.05	26.18
September	28.7	27.3	25.6	27.8	26.5	24.6

A partially replicated central composite design (Dykstra, 1960) of three replications was used in the two seasons of study. In that design, factorial and star points were replicated to obtain an estimate of error variance instead of central points as in the rotatable central composite design. The factors and levels of each factor are presented in the following table:

Levels	Coded	-S	-F	0	+F	+S
Factors						
Sowing date (SD)		10 – 5	20 – 5	30 – 5	10 – 6	20 – 6
Hill spacing (cm) (HS)	Actual	10 X 15	15 X 15	20 x 15	25 X 15	30 X 15
Zinc level(ZnSO4 kg/ha) (Zn)		0	12	24	36	48

S (-), S (+): star points, lowest and highest levels from studied factors, respectively.

F (-), F (+): factorial points, lower and higher levels from studied factors, respectively.

0: central levels from each factor.

Analyses of data were carried out according to Cochran and Cox (1957) using Statistica Ver. 7, Statssoft, 2012 and curves were obtained using Curve Expert.

The studied characters in that experiment included:

1-Grain yield (ton/ha): taken from the inner 3.0 m^2 of each plot and converted to tons/ha.

2-Number of effective tillers/m^2: taken from a random one-squared meter per plot in guarded rows.

3-Number of grains per panicle: average of three random panicles from each plot.

4- 100 – grain weight: average weight of three random samples, each of 100 random rice grains.

The meteorological data and analysis of data indicated the homogeneity of experimental conditions and error for the two seasons (Hartley, 1950), hence data of the experiment were averaged and analyzed. The year component and its interaction with applied factors was insignificant for all components, hence it was not included in the reported analysis of variance.

RESULTS AND DISCUSSION

RESULTS

Analysis of variance and regression analyses presented in table (3) revealed that number of effective tillers/m^2 was significantly and negatively affected by linear effect of sowing date, positively by linear effect of zinc level, and negatively by linear interactions of sowing date x hill spacing and sowing date x zinc levels. The model describing the relationship between the studied factors and number of effective tillers/m^2 is $Y = \beta_0 - \beta_1 SD + \beta_3 Zn - \beta_{12} SD \times HS - \beta_{13} SD \times Zn$, with R^2 value of = 0.93.

With regard to number of grains per panicle, that character was significantly and negatively affected by linear and quadratic effects of sowing date, and positively and negatively affected by linear and quadratic effects of hill spacing, respectively while it was positively and negatively affected by linear and quadratic effects of zinc levels, respectively. In addition, the linear interaction SD X HS was significant and negative. The model for that character is $Y = \beta_0 - \beta_1 SD - \beta_{11} SD^2 + \beta_2 HS - \beta_{22} HS^2 + \beta_3 Zn - \beta_{33} Zn^2 - \beta_{12} SD \times HS$, with R^2 value of 0.88.

On the other hand, 100- grain weight was significantly and negatively affected by linear effects of both sowing date and hill spacing, while it was positively affected by linear effect of zinc levels. In addition, the linear interaction HS X Zn was significant. The model describing the relationship between the studied factors and 100- grain weight is $Y = \beta_0 - \beta_1 SD - \beta_2 HS + \beta_3 Zn + \beta_{23} HS \times Zn$, with $R^2 = 0.69$.

Regarding grain yield / ha, the analysis showed a significant and negative linear effect for sowing date, significant and positive response for quadratic effects of sowing date and hill spacing, and both linear and quadratic effects of zinc levels. Hence, the model describing that character is $Y = \beta_0 - \beta_1 SD + \beta_{11} SD^2 + \beta_{22} HS^2 + \beta_3 Zn + \beta_{33} ZN^2$, with $R^2 = 0.89$.

Table 3. Analysis of variance and regression coefficients of effective tillers/m^2, number of grains/panicle, 100-grain weight and grain yield

Factors	No. of effective tillers/m^2		No. of grains per panicle		100- grain weight		Grain yield	
	MS	b	MS	b	MS	b	MS	b
Intercept	301.9*	-	191.8*	-	3.8*	-	4.5*	-
SD L	13763.5*	-57.9*	1082.4*	-5.14*	0.22*	-0.074*	8.30*	-0.45*
SD Q	1149.9	61.75	280.9*	-30.5*	0.024	-0.28	0.32*	1.03*
HS L	936.7	4.7	57.8*	1.18*	0.029*	-0.026*	0.14	0.05
HS Q	478.4	39.8	268.4*	-29.8*	0.018	-0.24	0.27*	0.95*
ZN L	3744.1*	30.2*	177.8*	2.07*	0.037*	0.030*	4.21*	0.32*
ZN Q	1341.6	66.7	271.2*	-29.9*	0.026	-0.29	0.44*	1.21*
SD L X HS L	2926.0*	-11.0*	48.1*	-1.4*	0.006	-0.016	0.081	-0.05
SD L X ZN L	2667.0*	-10.5*	0.66	-.16	0.0016	-0.008	0.081	-0.05
HS L X ZN L	651.04	-5.2	4.16	0.41	0.026*	0.033*	0.026	-0.03
Error	515.9		6.96		0.0063		0.06473	
R^2	0.93		0.88		0.69		0.89	

Data presented in Fig. (1-a) indicated the negative relationship between sowing date and number of effective of tillers/m^2, where a delay of one day in sowing would decrease number of effective tillers by about 4.76 tillers (r^2= 0.96). Means presented in table (4) indicated that the earliest sowing date, 10 May (S (-)), gave significantly higher number of effective tillers/m^2(564) compared to the latest sowing date, 20 June (S (+)) (389 tiller/ m^2). On the other hand, Fig. (1-b) revealed the positive relationship between that character and applied zinc levels, where every increase by 1kg of Zn would increase that character by 3.16 tillers (r^2= 0.88). Means in table (4) indicated that the

wider hill spacing (30 x 15) (S (+)) gave higher number of effective tillers (417) compared to narrow hill spacing (10 x 15) (S (-)) (412). The effect of the interaction between sowing date and hill spacing for number of tillers/ m^2 (fig. 1-c), indicated that the highest number of effective tillers was obtained in early sowing (10- 20 May) and wider hill spacing (25 x 15, 30 x 15). In addition, the increase in numbers of tillers/ m^2 in early sowing was higher than that in delayed sowing dates at wider hill spacing. The same trend of results was obtained for sowing date * zinc levels interaction (fig. 1-d).
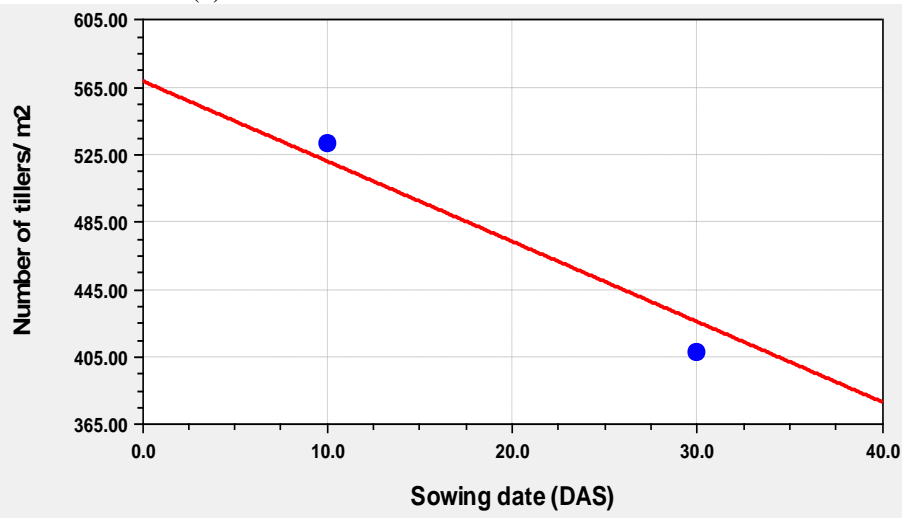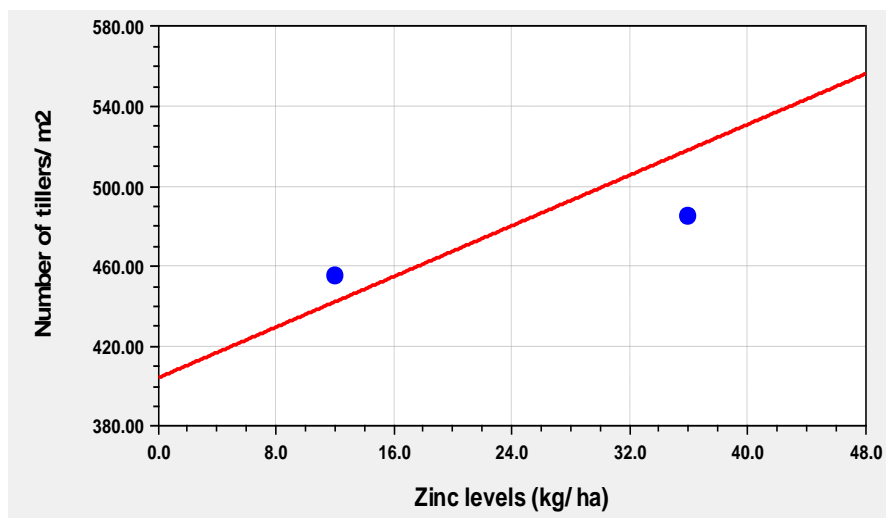

Fig. 1-a.

$\hat{Y} = 568.7 – 4.76 X, r^2 = 0.96$

Fig. 1-b.

$\hat{Y} = 404.25 + 3.16\ X$, r2 = 0.88

Table 4. Means of yield and yield components characters as affected by applied treatments

Points	Factors Sowing date	Hill spacing (cm)	Zinc levels (kg/ha)	No. of effective tillers/m²	No.of grain/panicle	100-grain weight(g)	Grain yield (t/h.)
F1	- 1	- 1	- 1	480	103.6	3.0	7.80
F2	- 1	- 1	+ 1	548	105.6	3.03	8.40
F3	- 1	+ 1	- 1	533	105.6	2.96	8.16
F4	- 1	+ 1	+ 1	567	109	3.03	8.53
F5	+ 1	- 1	- 1	406	98	3.0	6.96
F6	+ 1	- 1	+ 1	419	98	2.90	7.23
F7	+ 1	+ 1	- 1	402	94	2.80	7.0
F8	+ 1	+ 1	+ 1	406.6	98	2.93	7.23
S1	- 1	0	0	564	115.6	3.16	7.90
S2	+1	0	0	389	95.3	2.80	6.90
S3	0	- 1	0	412	103.6	3.13	7.06
S4	0	+1	0	417	111.3	3.03	7.23
S5	0	0	- 1	403	101.3	2.86	7.03
S6	0	0	+1	578	113	3.03	8.76
	LSD			37.86	4.97	0.118	0.42

Levels	Coded	-S	-F	0	+F	+S
Factors						
Sowing date (A)	Actual	10-5	20-5	30 - 5	10- 6	20-6
Hill spacing (cm) (B)		10x15	15x15	20 x 15	25x15	30x15
Zinc level (ZnSo4 kg/h)(C)		0	12	24	36	48

Fig. 1-c.

the highest number of grains/panicle (111.3) compared to narrow hill spacing (10 x 15) (S (-)) (103.6).
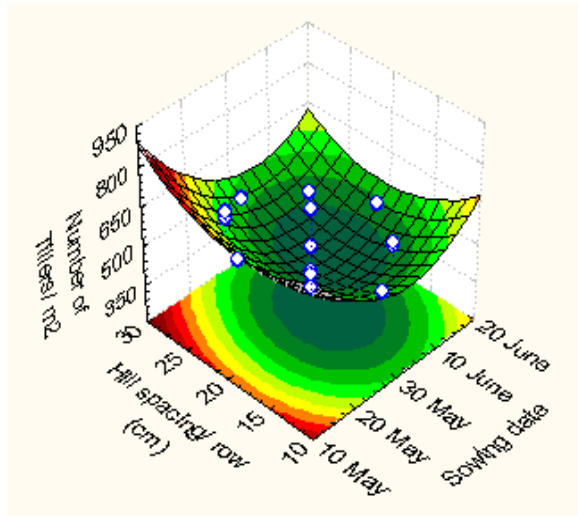

Fig. 1-d.

Data presented in Fig. (2-a) showed the negative relationship between sowing date and number of grains per panicle as affected by linear and quadratic effects where a delay of one day in sowing would decrease number of grains per panicle by 1.08 and 0.31 grains, (r^2= 0.83 and 0.90), respectively. Means in table (4) indicated that early sowing on 10 May (S (-)) gave the highest number of grains/panicle (115.6) and that character decreased significantly with delaying sowing to 20 June (S (+)) (95.3).

Data presented in Fig. (2-b) indicated the negative relationship between number of grains per panicle and hill spacing as affected by linear and quadratic effects, where every increase of 1.0 cm in spacing would decrease that character by 0.32 and 2.87 grain, (r^2 = 0.4 and 0.94), respectively. The data in table (4) also, revealed that wider hill spacing (30 x 15) (S (+)) gave
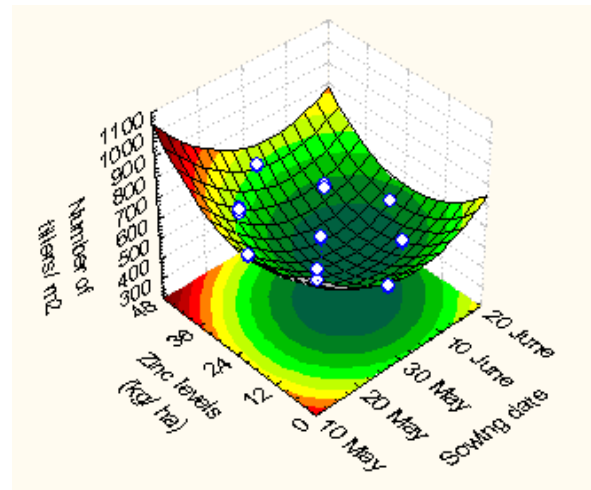
Data presented in Fig. (2-c) revealed the positive relationship between number of grains per panicle and applied zinc levels as affected by linear and quadratic effects, where every increase of 1kg of Zn would increase that character by 0.21 and 0.40 grains (r^2= 0.64 and 0.94), respectively. On the other hand, data in table (4) showed that the application of highest level of zinc (48 kg $ZnSO_4$/ha) (S (+)) gave significantly the highest number of grains (113) compared to no zinc (S (-)) application (101.3). The effect of the interaction between sowing date and hill spacing for number of grains/ panicle (fig. 2-d), indicated that the highest number of grains/panicle was obtained in early sowing (10- 20 May) and wider hill spacing (30 x 15 cm).
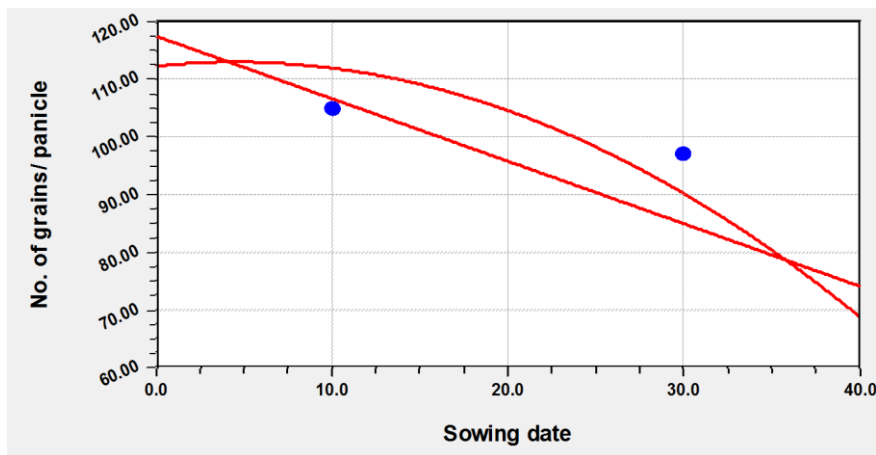

Fig. 2-a.

(L): $\hat{Y}$ = 117.48 – 1.08 X (r^2 = 0.83)
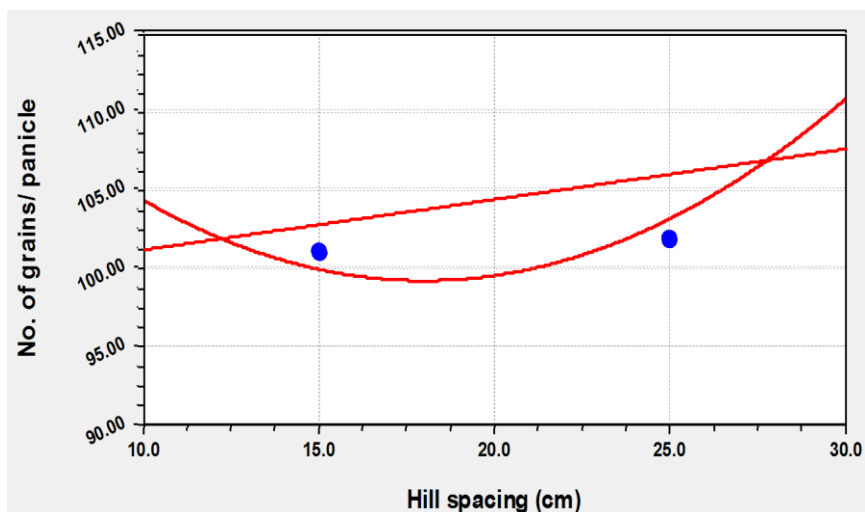(Q): $\hat{Y}$ = 112.23 + 0.31 X – 0.035 X^2 (r^2 = 0.90)

Fig. 2-b.

(L): $\hat{Y} = 98.03 + 0.32\ X\ (r^2 = 0.4)$
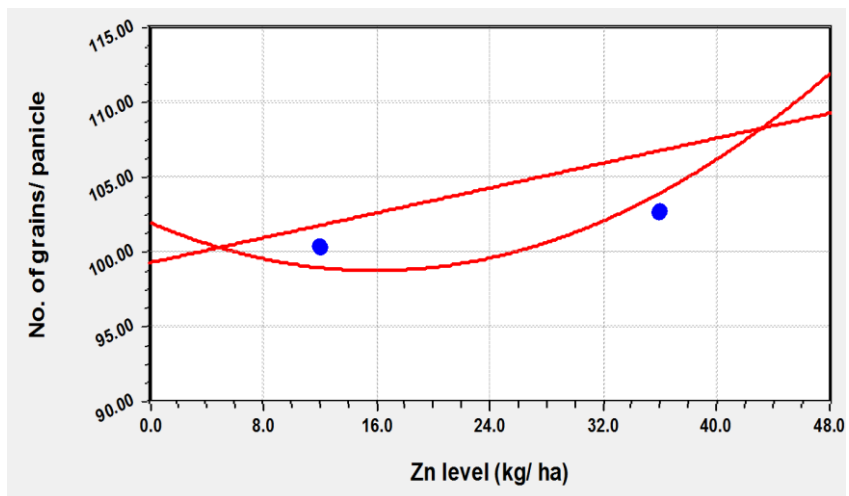(Q): $\hat{Y} = 125.06 - 2.87\ X + 0.08\ X^2\ (r^2 = 0.94)$

Fig. 2-c.

(L): $99.24 + 0.21\ X\ (r2 = 0.64)$
(Q): $\hat{Y} = 102 - 0.40\ X + 0.013\ X2\ (r2 = 0.94)$

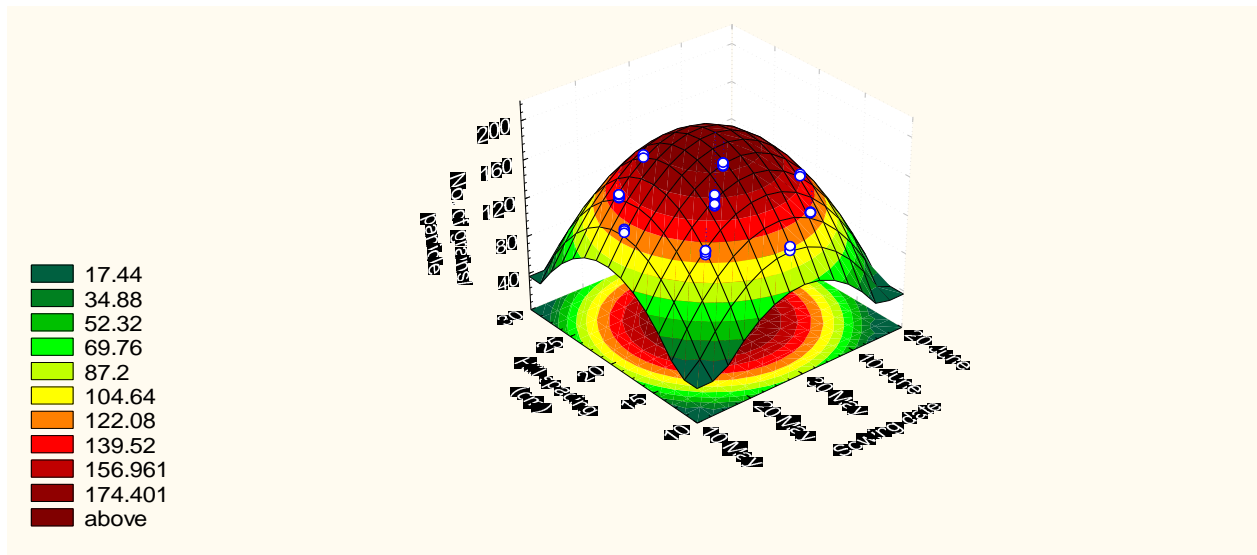|	
■	17.44
■	34.88
■	52.32
■	69.76
■	87.2
■	104.64
■	122.08
■	139.52
■	156.961
■	174.401
■	above

Fig. 2-d.

Data presented in Fig. (3-a) indicated the negative relationship between 100- grain weight and sowing date where a delay of one day in sowing would decrease 100- grain weight by about 0.008 g (r^2= 0.92). Means in table (4) indicated that early sowing on 10 May (S (-)) gave the heaviest 100- grain weight (3.16 g) and that character decreased significantly with delaying sowing to 20 June (S (+)) (2.80 g). Data presented in Fig (3-b) indicated the negative relationship between that character and hill spacing where the increase of spacing would decrease 100- grain weight by about 0.005 g (r^2= 0.28). The data in table (4) also, revealed that wider hill spacing (30 x 15) (S (+)) gave lower 100- grain weight (3.03 g) compared to narrow hill spacing (10 x 15) (S (-)) (3.13 g).

On the other hand, Fig. (3-c) revealed the positive relationship between 100- grain weight and applied zinc levels, where every increase by 1kg of Zn would increase that character by 0.003 g (r^2= 0.90). The data in table (4) showed that application of highest level of zinc (48 kg $ZnSO_4$/ha) (S (+)) gave significantly higher 100- grain weight (3.03 g) compared to no zinc (S (-)) application (2.86 g). The effect of the interaction between zinc level and hill spacing for 100- grain weight (fig. 3-d), indicated that the heavier 100- grain weight was obtained with highest level of zinc (48 kg $ZnSO_4$/ha) and wider hill spacing (30 x 15 cm).
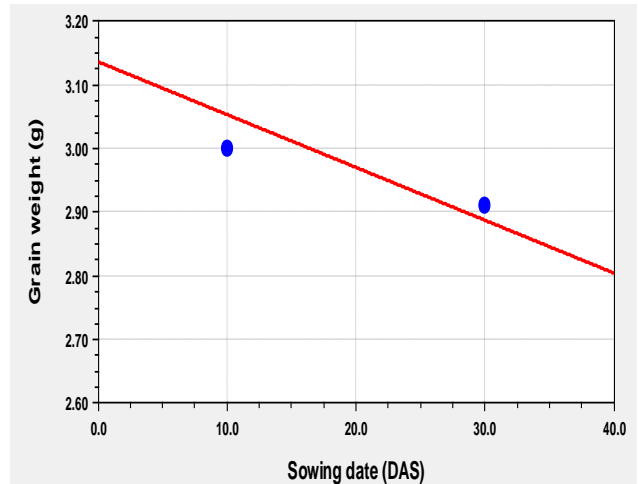

Fig 3-a.
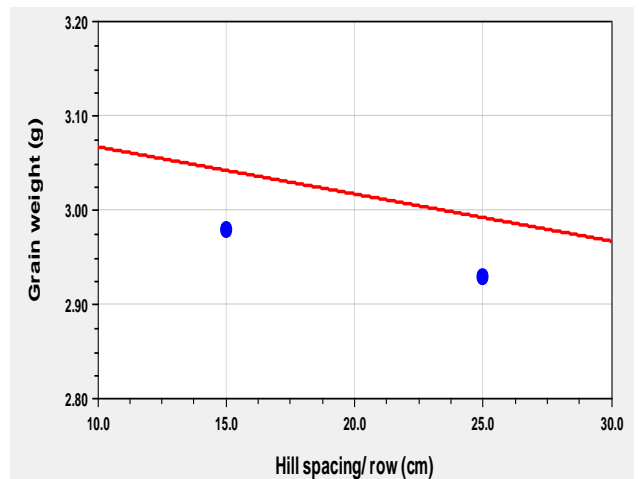
$\hat{Y} = 3.14 - 0.008\ X,\ r^2 = 0.92$
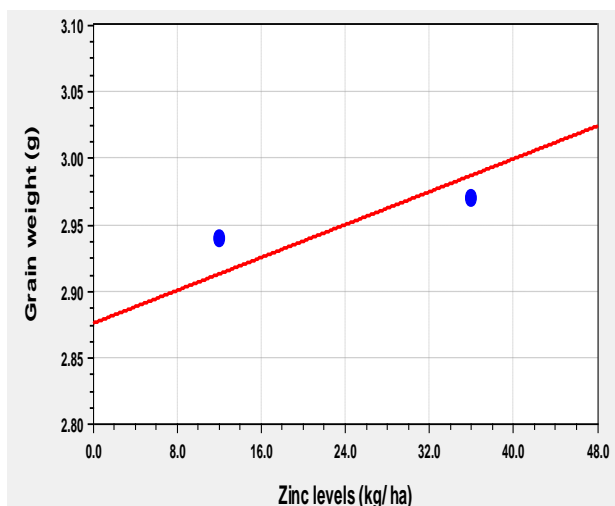

Fig 3-b.

$\hat{Y} = 3.11 - 0.005\ X,\ r^2 = 0.28$

Data presented in Fig. (4-c) showed the positive relationship between grain yield/ ha and applied zinc levels as affected by linear and quadratic effects, (r2= 0.90 and 0.92, respectively). The data in table (4) indicated that the application of highest level of zinc (48 kg ZnSO4/ha) (S(+)) gave significantly higher grain yield (8.76 t/ha) compared to no zinc (S(-)) application (7.03 t/ha).

Fig 3-c.

$\hat{Y} = 2.87 + 0.003$ X, $r^2 = 0.90$

Fig 3-d.
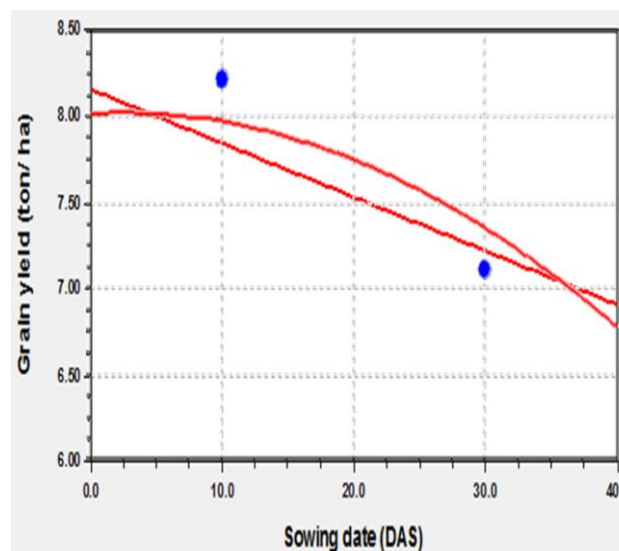
Fig. 4-a.

L: $\hat{Y} = 8.15 - 0.03$ X, $r^2 = 0.81$
Q: $\hat{Y} = 8.02 + 0.004$ X $- 0.0008$ X^2, $r^2 = 0.86$
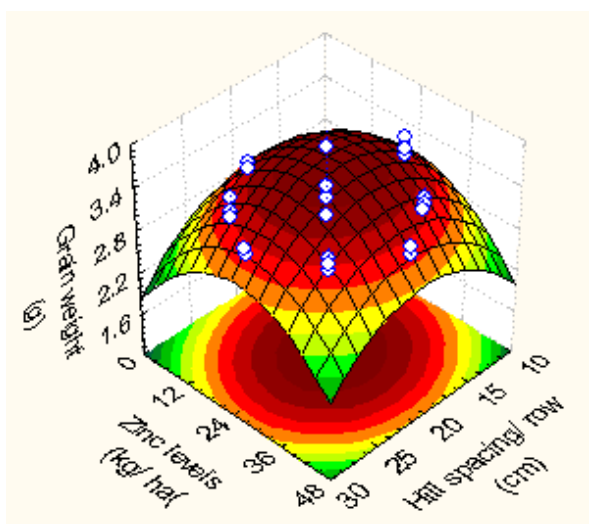
Data presented in Fig. (4-a) indicated the negative relationship between grain yield/ ha and sowing date as affected by linear and quadratic effects, where a delay of one day in sowing would decrease that character by 0.03 and 0.004 t / ha, (r²= 0.81 and 0.86), respectively. Means in table (4) indicated that early sowing on 10 May (S (-)) gave high grain yield (7.90 t/ha) and that character decreased significantly with delaying sowing to 20 June (S (+)) (6.90 t/ha).

Data presented in Fig. (4-b) revealed the positive relationship between grain yield/ ha and hill spacing up to 23 x 15 then gradually decreased as hill spacing was increased (r² = 0.98). The data in table (4) also, revealed that wider hill spacing (30 x 15) (S (+)) gave higher grain yield (7.23 t/ha) compared to narrow hill spacing (10 x 15) (7.06 t/ha).

Fig. 4-b.

$\hat{Y} = 4.87 + 0.28$ X $- 0.006$ X2, r2 = 0.98

Fig. 4-c.

L: $\hat{Y} = 7.01 + 0.03\,X$, r2 = 0.90

Q: $\hat{Y} = 7.12 + 0.006\,X + 0.0005\,X2$, r2 = 0.92.
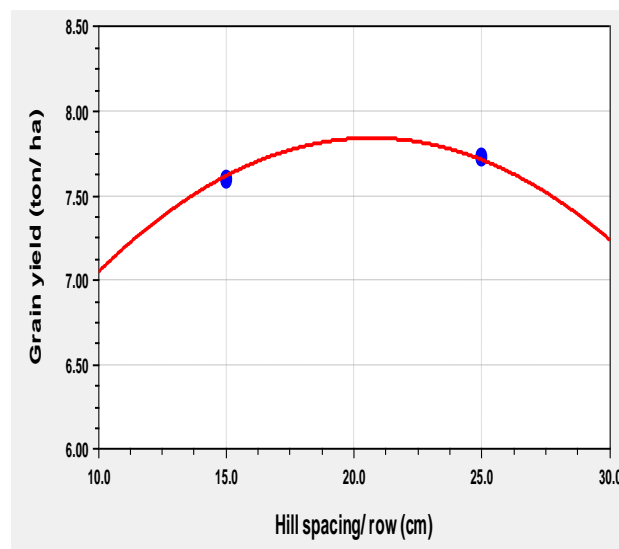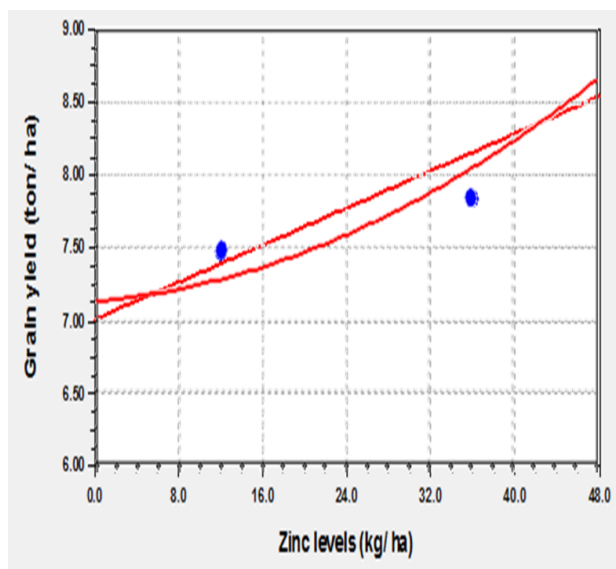
DISCUSSION

The present investigation was carried out to study the effect of three factors, i.e.; sowing date, hill spacing and zinc application level, and their interactions on yield and yield components of rice cultivar Sakha 106. The factorial points for each factor were: sowing date (20 May and 10 June), hill spacing (15 x 15 cm and 25 x 15 cm) and zinc fertilizer levels (12 and 36 kg $ZnSO_4$/ha). Application of the partially replicated central composite design added two more levels (star points) for each factor, viz. 10 May and 20 June for sowing date, 10 x 15 and 30 x 15cm for hill spacing and 0 and 48 kg Zn SO_4/ha for Zinc fertilizer levels.

Data revealed that number of effective tillers decreased linearly with delaying sowing up to 20 June (Fig 1-a). That may be attributed to the incidence of high temperatures in delayed sowing causing the plants to switch rapidly to the reproductive stage thus decreasing the tillering capacity of the rice plant and the number of grain–bearing tillers. Similar findings were reported by Safdar *et al*. (2008) and Mrudhula and Rao (2020). Increasing the application of zinc fertilizer linearly increased number of effective tillers/m^2 (Fig 1-b). It has been reported that zinc plays an important role in rice tillering (Alloway, 2008) and fertility of spikelets (Fageria, 2009) for its role in pollen grain formation and viability. Amanuallah *et al*. (2020) found that increasing zinc levels led to increase number of fertile tillers/m^2. The interaction between sowing date and hill spacing (Fig 1-c) further showed that the highest number of effective tillers/m^2 was obtained at the earliest sowing date (10 May) and widest hill spacing (30 x

15),however decreasing hill spacing causes a decrease in that character. That may by be due to a direct effect for higher competition between plants, in high plant density, for ground space, leading to increasing vegetative growth and decreasing the production of tillers.

This is in agreement with the results reported by Anwari *et al*. (2019) and Rex Immanuel *et al*. (2020).

The same trend was observed for sowing date x zinc fertilization level interaction, where early sowing and higher applied zinc levels increased number of effective tillers/m^2. Similar findings were reported by Sudha and Stalin (2015) and Dhakad *et al*. (2020) who reported that increasing zinc application levels increased fertility and number of tillers/ m^2.

Regarding number of grains/panicle, delaying sowing date (Fig 2-a) linearly and quadratically decreased that character, and that may be due to the coincidence of grain setting and filling stage of rice plant with adverse environmental conditions, i.e. high temperature, that affects pollen viability and the process of fertilization. Safdar *et al*. (2008) and Shabana *et al*. (2016) found the delayed sowing of rice led to a considerable decrease in number of grains/panicle. On the other hand, number of grains/panicle was increased with wider hill spacing (Fig 2-b). The linear relationship between number of grains/panicle and hill spacing was not conclusive (r^2= 0.4) whereas the quadratic relationship (r^2= 0.94) revealed that at narrower hill spacing, that character was decreased up to 20 x 15, then tended to increase with increasing hill spacing up to 30 x 15cm. Wider hill spacings decreases intra-competition between rice plants for growth resources, hence rice plants are nutritionally balanced. In addition, wider spacings allow for more light penetration into the canopy and thus increases photosynthesis and photosynthates production which beneficially affects fertility percentage in the panicle and increases grain setting. Similar findings were reported by Pokharel *et al*. (2018) and Anwari *et al*. (2019). Application of zinc sulphate levels followed the same trend of hill spacing (Fig 2-c), where applied levels above 20 kg $ZnSO_4$/ha showed a gradual and substantial increase in number of grains /panicle up to 48 kg $ZnSO_4$/ha. As reported by Alloway (2004) and Fageria (2009), zinc plays a major role in chlorophyll production and photosynthesis, metabolism of starch, pollen grain viability and grain setting. All that will affect number of grains/panicle, and hence, zinc deficiency will cause a reduction in that character (Alam and Kumar, 2015 and Mahmudi *et al*., 2015). The sowing date x hill spacing interaction (Fig 2-d) revealed that the highest number of grains/panicle resulted from sowing on May 30 and hill spacing of 20 x 15cm. Increasing the level of either factors, delayed

sowing and narrower hill spacings, will decrease that character.

With regard to 100-grain weight (HGW), data revealed that this character followed the same trend as number of grains/panicle for sowing date (Fig 3-a) and zinc fertilizer level (Fig 3-c). HGW decreased with delaying sowing (Abou Khalifa and EL- Rewainy, 2012 and Abou Khalifa et al., 2014) and increased with increasing $ZnSO_4$ levels (Ali et al. ,2014 and Mahmudi et al., 2015). On the other hand, a decrease in that character was observed with wider hill spacings above 20 x 15 cm (Fig 3-b). That could be a result of increased number of grains/panicle which lead to a reduction in single grain weight. Similar findings were reported by Kandil et al. (2010) and Uddin et al. (2011) who found that increasing hill spacing beyond 20 x 15 cm reduced grain weight.

The hill spacing x zinc level interaction (Fig 3-d) indicated that highest values for HGW resulted from sowing at 20 x 15cm hill spacing combined with application of 24 kg ZnSO4/ha. Narrower hill spacings and higher zinc fertilizer levels reduced that character.

Grain yield showed a linear and negative relationship with sowing date (Fig 4-a). Delaying of sowing resulted in decreasing number of effective tillers/m2, number of grains/panicle and 100- grain weight and that resulted in reduction of grain yield/ha. Similar results were reported by Pal et al. (2017) and Huang et al. (2020) who concluded that adverse environmental conditions (high temperature) affected panicle fertility levels and decreased grain weight, and consequently grain yield was reduced. With regard to the effect of hill spacing, the data (Fig 4-b) revealed a gradual increase in grain yield up to 20 x 15 cm then gradually decreased at the widest hill spacing of 30 x 15 cm. That may be interpreted by the compensation ability of rice plants to increase the number of effective tillers with the increase in hill spacing up to 20 x 15 cm. However, increasing the spacing to 30 x 15cm reduced grain yield as a result to the decrease in number of fertile tillers/ m2. Several researchers reported that 20 x 15 cm gave higher yields than narrower or wider spacings (Aklilu et al. 2020 and Rex-Immanuel et al.,2020). Moreover, grain yield showed a linear and quadratic increase with increasing zinc fertilizer level (Fig 4-c). As reported by several investigators, zinc has beneficial effects on tillering (Alloway, 2008), fertility and grain formation (Fageria, 2009) and grain weight, through increasing photosynthesis and dry matter production (Abou Khalifa and EL-Rewainy,2012), and consequently increase grain yield. These findings were in agreement with those reported by Dhakad et al. (2020), and Huang et al. (2020).

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الملخص العربي

تأثير ميعاد الزراعة والمسافات بين الجور ومستوي التسميد بالزنك علي محصول الحبوب ومكوناته في صنف الأرز سخا ١٠٦

خيرالله عبدالنبي شفيق شبل، علي عيسي نوار ، حسام الدين محمد إبراهيم ، عبدالسلام عباس عبدالسلام

أجريت تجربتين حقليتين في الموسم الصيفي لعامي ٢٠١٨ و٢٠١٩ بمحطة البحوث الزراعية، جامعة الإسكندرية ، وكان الهدف من هذه التجارب دراسة تأثير ميعاد الزراعة (١٠ مايو ، ٢٠ مايو ، ١٠ يونيو و ٢٠ يونيو)، المسافات بين الجور (١٠ × ١٥ ، ١٥ × ١٥ ، ٢٥ × ١٥ و ٣٠ × ١٥ سم) ومعدل سماد كبريتات الزنك (٠ ، ١٢ ، ٣٦ ، ٤٨ كجم للهكتار)، علي محصول الحبوب ومكونات المحصول في صنف الأرز سخا ١٠٦. التصميم الإحصائي المستخدم في كلا الموسمين هو تصميم مركب مركزي مكرر، حيث تم تكرار النقاط العاملية والمحورية ثلاث مرات. أوضحت النتائج أن التأخير في ميعاد الزراعة أدى إلى نقص في وزن المائة حبة، محصول الحبوب (بعد ١٠ مايو) وعدد الخلفات الحاملة للسنابل وعدد الحبوب في النورة (بعد ٣٠ مايو). وجد أن أفضل مسافة بين الجور هي (٢٠ × ١٥ سم) حيث أعطت أعلي عدد من الحبوب في النورة وأعلي وزن مائة حبة ومحصول حبوب للهكتار بينما أعطت المسافة ٣٠ × ١٥ سم أعلي عدد من الخلفات الحاملة للسنابل. إضافة سماد كبريتات الزنك بمعدل ٤٨ كجم / هكتار أدت إلى زيادة المحصول ومكوناته. ولذلك يمكن التوصية، بزراعة الصنف سخا ١٠٦ مبكرا في ١٠ مايو، بمسافات بين الجور ٢٠ × ١٥ سم وإضافة كبريتات الزنك وذلك بمعدل ٤٨ كجم للهكتار للحصول علي محصول حبوب عالي نتيجة للتحسين في مكونات المحصول.