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Selection for Yield, Rust Resistance and Quality Traits in Early Generations of Giza 171 × Sids 12 Cross of Bread Wheat

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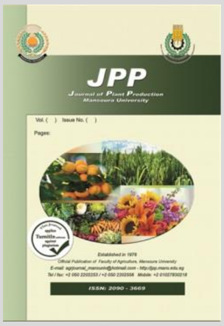

ABSTRACT

The F_2 and F_3 populations resulting from Giza171 × Sids12 hybrid were used from 2016 to 2019 seasons at Sakha Agricultural Research Station to study the inheritance of some agronomic characters and resistance to rusts diseases and select new bread wheat families with high yield potential and good grain quality. Giza171 was preferable for yield and its components, while Sids12 was desirable for earliness characters. The ranges of the F_2 and F_3 populations went out the means of its parents for the studied characters. All characters showed moderate to high values of broad sense heritability in F_2 and F_3 generations. The best responsive characters to selection in F_2 were No. spikes plant^{-1} and grain yield plant^{-1}, while days to maturity was the least responsive character. F_3 families had highly significant variations for all studied characters. Correlation coefficients referred that grain filling rate, followed by No. spikes m^{-2}, then kernels weight spike^{-1}, later the No. kernels spike^{-1} had the most impact on grain yield in F_3 families. The resistance of yellow and leaf rusts was controlled by two dominant genes and stem rust was controlled by two complementary dominant genes. Thirteen promising families were high yielding, resistant to the three rusts and have appropriate height were selected to promote to the next advanced of segregating generations and five of them were preferable for grain quality of wheat.

Keywords: Bread wheat, selection, rusts, resistance genes, yield components, grain quality.

INTRODUCTION

Wheat is the principal staple food in Egypt in terms of area and consumption. According to McGill *et al*., (2015), wheat constituted 58 percent of cereal consumption as food and one-third of cereal consumption as feed in terms of quantity, in addition represent one-third of the total daily calorie intake per person in Egypt. Wheat national production-consumption gap is a major economy dilemma in Egypt, where 49 % of wheat national consumption was imported in 2013 and it will reach 63 % under climate change in 2030 (Ouda and Zohry, 2017). To cope with such a daunting challenge, the Egyptian wheat breeding program aim to release new cultivars with high grain yield and desirable agronomic attributes, along with good quality.

The three rusts, stem (or black), leaf (or brown) and stripe (or yellow) caused by fungi *Puccinia graminis* f. sp. *tritici*, *P. triticina* and *P. striiformis* f. sp. *tritici*, respectively, continue to cause losses, often major, in various parts of the world and hence receive high attention in breeding (Singh *et al*., 2011). Developing and deploying genetically resistant varieties resistance to wheat rusts are the most economical and environmentally friendly strategy for controlling rust diseases of wheat.

In most developing countries, apart from grain yield and disease resistance, grain quality has not been a strong criterion for variety selection. However, the Egyptian farmers are critically looking for high-quality varieties suited for the preparation of a range of end products. Tadesse *et al*. (2017) revealed that because of the negative correlation of yield and these quality traits, it may be difficult to combine high-yield potential with high grain content. In light of this, it is important goal to use excellent cultivars in grain quality traits with those of high productivity and then select germplasms that combine good quality and high yield.

Our study aimed to (1) investigate the inheritance of some agronomic characters in the second and third segregating generations of Giza 171 x Sids 12 hybrid, (2) select new bread wheat families with high yield potential, resistance to rust diseases and good grain quality, and (3) investigate the inheritance of wheat rusts in F_2 and F_3 populations.

MATERIALS AND METHODS

This study was conducted during 2016, 2017, 2018 and 2019 wheat seasons at the Experimental Farm and the Lab of Seed Technology Res. Sec. of Sakha Agricultural Research Station, Kafr El-Sheikh, Egypt (31° 5' 12" North, 30° 56' 49" East). The hybrid of the two bread wheat cultivars Giza 171 and Sids 12 has been selected based on Farhat and Mohamed (2018) results, since exhibited acceptable grain yield and rust reactions, along with good grain quality.

The parentages and pedigree of Giza 171 are: SAKHA 93/GEMMEIZA 9 (S.6-1GZ-4GZ-1GZ-2GZ-0S) and Sids 12 are:

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).

The two parents were crossed in 2016 to produce the F_1 hybrid. In season of 2016/2017, the two parents and their F_1

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were sown to produce new F_1 hybrid and F_1 plants were selfed to obtain the F_2. In season of 2017/2018, seeds of 50 plants from the two parents and their F_1 and 200 plants from their F_2 were planted on 25 November. The plants were spaced with 25 cm among rows and 10 cm within rows. One hundred plants were randomly selected to pass to F_3 and evaluated together with the two parents, their F_1, and F_2 on 20 November in season of 2018/2019. The two parents and their F_1 were represented with 50 plants and their F_2 with 200 plants in 25 and 10 cm between and within rows. F_3 were represented with 100 families, each family was planted in 1.75 m long row with 25 and 5 cm among and within rows. F_3 families along with the two parents as checks were laid out in randomized complete block design (RCBD) experiment with three replications. The experiment was surrounded by mixed wheat genotypes, which were highly sensitive to yellow, leaf and stem rusts as a spreader. The average minimum and maximum temperature and relative humidity were 25.4 and 18.1 °C and 62.7 % in the first season and, 23.4 and 17.8 °C and 68.7 % in the second season, respectively. Recommended agricultural practices for wheat cultivation in delta region (old land) in Egypt were applied at the proper time. The preceding crop was maize (*Zea mays*, L.) in the two seasons.

Agronomic characters were collected on individual plants for the two parents and their F_1 and F_2 and on plot basis for F_3 families. The studied characters for the two parents and their F_1 and F_2 were number of days to heading and maturity, grain filling period (day), plant height (cm), No. of spikes plant^{-1}, 100-kernel weight (g) and grain yield plant^{-1} (g). For F_3, the characters were days to heading and maturity, grain filling period (day) and rate (g day^{-1} m^{-2}), plant height (cm), No. of spikes m^{-2}, 1000-kernel weight (g) and grain yield m^{-2} (Kg).

Yellow, leaf and stem rusts were recorded on individual plants under field conditions in season of 2018/2019 only. The infection types of rusts were classified as resistant (R), moderately resistant (MR), moderately susceptible (MS) and susceptible (S) and the disease severity were recorded according to Stakman *et al.,* (1962). Chi-square test ($\chi 2$) was used to test the significance of difference between observed and expected ratios in F_2 and F_3 populations for the rusts reactions according to Steel *et al.,* (1997). The reactions to rusts were categorized in F_2 population into resistant (infection types of O, R, and MR) and susceptible (infection types of MS and S), while the F_3 population were categorized as homozygous resistant, homozygous susceptible and segregants family.

Quality characters were estimated only for the selected F3 families using seed samples taken randomly in bulk. The studied characters were, the crude protein according to (AOAC, 1990), wet and dry gluten percentage as described by (Pleshkov, 1976) and hydration capacity percentage of gluten ([wet gluten – dry gluten] × 100 / dry gluten) were calculated.

The phenotypic (σ^2_p), genotypic (σ^2_g) and environmental (σ^2_e) variances were obtained using parents and their F_2 crosses as outlined by Cruz *et al.* (2012). F ratio was calculated for testing the significance of the differences between F_2 variance and the corresponding environmental variance. Broad sense heritability (h^2 %) was calculated and equal to σ^2_g / σ^2_p ×100, according to Acquaah (2012). Selection differential (S), the expected response to selection (RS), the expected response to selection, expressed as % of the base population mean (RS %) and the expected genetic gain (PGG) were calculated using the formulas reported by Cruz *et al.* (2012).

$$\mathbf{S = (\bar{X}_S - \bar{X}_O),}$$
$$\mathbf{RS = S * H^2 \text{ and}}$$
$$\mathbf{RS\ (\%) = 100 * RS/ \bar{X}_O.}$$

Where, $\bar{X}_S$ $\bar{X}_O$ and H^2 represent mean of progeny selected, mean of F_2 population and heritability in broad sense, respectively.

The statistical analyses were performed using the statistical routines available in Microsoft EXCEL (2016).

Regarding the F_3 population, the studied 100 families and their two parents as checks were subjected to analysis of variance as in Steel *et al.* (1997) and differences between genotypes' means were tested with LSD at 5% level of probability. Different variance components were calculated following the procedure indicated in Fehr (1993) as follows: genotypic variance (σ^2_g) = (genotype mean square − error mean square)/number of replications; phenotypic variance (σ^2_p) = environmental variance + genetic variance; and residual (error) variance (σ^2_e) = environmental variance. Broad-sense heritability = (genetic variance/phenotypic variance). Nature degree of dominance (Potence ratio), the inbreeding depression percentage and the phenotypic and genotypic coefficients of variation was computed as in Mather and Jinks (1982). Simple correlation was worked for the F_3 families according to Steel *et al.* (1997).

RESULTS AND DISCUSSION

In general, and from the wheat breeder's point of view, the characters of days to heading and maturity, grain filling period, plant height and rust infection were preferred when its values and related genetic parameters are in decreased or negative direction unlike grain yield and its components.

Mean performance for the F_2 population

Table 1 show descriptive statistics of the studied characters for Giza171 and Sids12 and their F_1 and F_2 populations in the two seasons. The season of 2018/2019 had higher values of all the studied characters compared to season of 2017/2018. Compared to Sids 12, Giza 171 was later for heading and maturity, had short grain filling period, taller and higher for No. of spikes palnt^{-1} and grain yield plant^{-1}, while lower for No. of kernels spike^{-1} and 100-kernel weight in the two seasons. Giza 171 and Sids 12 were used in many previous studies and our results are in line with their findings of (Farhat and Mohammed, (2018) and Darwish *et al*., (2018a&b).

The means of F_1 was higher than or close to the corresponding high parents means for days to heading, plant height and grain yield plant^{-1} in the second season; for grain filling period in the first season and for No. kernels spike^{-1} and 100- ernel weight in the two seasons. Moreover, the means of the F_1 were less than or nearest to the corresponding lowest parent mean values for days to heading and grain yield plant^{-1} in the first season and for No. of spikes plant^{-1} in the two seasons.

The means of F_2 was higher than the means of the two parents for days to heading and maturity in the first season, grain filling period and plant height in the second season and for No. of kernels spike^{-1} in the two seasons. Further, the means of the F_2 fallen less than or nearest to the corresponding lowest parent mean values for grain filling period, plant height and grain yield plant^{-1} in the first season and for No. of spikes plant^{-1} and 100-kernel weight in the two seasons. Meanwhile, the F_2 means exhibited intermediate scores between the two parents for the days to heading and maturity and No. of spikes plant^{-1} in the second season. the ranges of the F_2 values went out the means of Giza 171 and Sids 12 for the studied characters, indicating the amount of the variability produced from segregation in the F_2 plants even the two parents were not differed significantly and Giza 171 and Sids 12 were different genotypically (Table l).

Table 1. Means and their standard error and variance of the studied characters for Giza171 and Sids12 and their F_1 and F_2 populations in 2017/2018 and 2018/2019 seasons.

Parent/generation		Days to heading		Days to maturity		Grain filling period (days)		Plant height (cm)	
		2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019
Giza 171	Mean	88.2±0.25	105.42±0.25	131.76±0.36	153.4±0.26	43.56±0.34	48.02±0.23	91.52±0.7	107.69±1.08
	Variance	1.58	4.33	3.27	4.49	2.92	3.52	12.3	15.06
Sids 12	Mean	82.54±0.25	101.98±0.42	127.25±0.17	150.94±0.32	44.71±0.3	49±0.41	80.44±0.65	96.92±0.7
	Variance	1.48	7.74	0.72	3.58	2.22	5.2	10.03	6.41
Parents mean		85.37	103.7	129.51	152.17	44.13	48.51	85.98	102.31
F_1	Mean	84.94±0.24	104.65±0.77	129.52±0.23	151.79±0.46	44.58±0.26	47±0.5	86.33±0.78	105±1.83
	Variance	1.58	11.71	3.27	3.95	2.92	4.67	12.3	20
F_2	Mean	89.27±0.32	103.48±0.33	132.02±0.29	152.72±0.22	42.74±0.22	49.25±0.2	78.56±1.03	107.44±1.36
	Range	80-102	93-118	126-145	146-159	36-51	39-61	55-104.5	65-135
Parent/generation		No. of spikes plant^{-1}		No. of kernels spike^{-1}		100-kernel weight (g)		Grain yield plant^{-1} (g)	
		2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019
Giza 171	Mean	15.79±0.27	19.3±0.68	71.56±0.59	75.0±0.48	3.59±0.08	3.92±0.06	23.38±0.6	26.35±0.9
	Variance	1.74	12.6	8.59	17.12	0.17	0.28	8.88	13.74
Sids 12	Mean	7.71±0.19	9.37±0.61	81.67±0.98	85.11±0.61	3.65±0.06	4.31±0.04	15.27±0.45	19.79±0.93
	Variance	0.82	11.07	23.19	17.21	0.09	0.07	4.83	16.4
Parents mean		11.75	14.33	76.61	80.05	3.62	4.12	19.33	23.07
F_1	Mean	9.52±0.19	12.33±0.98	82.42±0.44	82.5±0.61	3.63±0.08	4.12±0.07	18.84±0.57	27.88±1.94
	Variance	1.74	14.52	8.59	6.62	0.17	0.07	8.88	63.99
F_2	Mean	5.238±0.28	10.62±0.47	81.99±0.86	81.64±1.24	3.08±0.08	3.16±0.09	12.69±0.36	23.02±1.19
	Range	3-20	3-34	50-103	40-106	2-5.85	2-6.27	9.6-48	10-62

The means of the parents and their F_1 and F_2 and the other advanced generations were exhibited in many preceding investigations. Such as Ragab (2010), Zaazaa *et al*. (2012) and Darwish *et al.* (2018a) who found that the mean value of the F_2 population comparing with their parents was higher than the highest parent for grain yield and its components in many cases.

Table 2 shows some genetic parameters for the two parents and their F_1 and F_2 in the two seasons. The phenotypic variances in the F_2 were differed significantly ($P < 0.05$ or 0.01) with the environmental variances in the two parents and F_1 for the studied characters and therefore the F_2 plants had sufficient variability to estimate the genetic parameters.

The highest phenotypic, genetic and environmental variances were detected for plant height, No. of spikes plant^{-1}, No. of kernels spike^{-1} and grain yield plant^{-1} in the two seasons. The genetic variance exceeded the corresponding environmental variances for all studied characters in the two seasons, except for grain filling period in the second season.

All characters showed moderate to high values of broad sense heritabilities in the two seasons and ranged from 36.03 % for grain filling period to 95.72 % for plant height in the 2nd season. The heritability percentages were fluctuated in the two seasons for days to heading and maturity and grain filling period, emphasizing the role of seasonal environmental wheat breeding.

Heterosis percentages were significant for all characters under the two seasons, except for days to maturity in the second season. Desirable heterosis were observed for all characters under the two seasons, except for days to heading and maturity in the two seasons and grain filling period in the first season.

Partial dominance range was defined for all characters under the two seasons, except for grain filling period, No. of kernels spike^{-1} and grain yield plant^{-1}, which had over-dominance range in the desirable direction. In general, as known the over-dominance range played the major contribution in the expression of hybrid vigor and heterosis effects followed by dominance range. Characters of spikes number plant^{-1}, 100-kernels weight and grain yield plant^{-1} exhibited the highest positive inbreeding depression values under the two seasons.

Phenotypic (PCV%) and genetic (GCV%) coefficient of variation had medium to high values for grain yield plant^{-1}and its components and plant height, while had lower values for days to heading and maturity and grain filling period in the two seasons, indicating presence of genetic potential and selection may be effective. The GCV values were slightly lower than that of PCV, indicating that the environment had an important role in the expression of these characters. The variance and its components and related parameters were investigated by many researchers and their results were in line with obtained here (El-Sayed, 2015; Hermas and El-Sawi, 2015 and Ali, 2017).

Predicted genetic gain from Selection in F_2 to F_3

Knowledge of the expected response to selection and the consequent expected genetic gains are essential to identify the appropriate selection criteria (Acquaah, 2012). The predicted genetic gain from selectin and the paraments used in its estimation are presented in Table 3.

The selection differential ranged from 1.64 g for 100-kernel weight to -30.19 cm for plant height in the second season. The same trend was observed for the expected responses to selection with values of 1.42 and 28.9, respectively. The best responsive characters to 10 % selection intensity based on percentage of expected responses to selection to the F_2 mean were No. of spikes plant^{-1} (108.35) in the first season and grain yield plant^{-1} (106.56) in the second season, while the least responsive one was days to maturity (-1.67) in the second season.

Table 2. Estimates of phenotypic (σ_p^2), genotypic (σ_g^2) and environmental (σ_e^2) variance components, broad sense heritability (h^2), heterosis based on better, potence ratio, inbreeding depression (ID), and phenotypic (PCV%) and genetic (GCV%) coefficient of variation for the studied characters of cross Giza 171, Sids 12, their F_1 and F_2 in the two seasons of 2017/18 and 2018/19.

Parameter	Days to heading		Days to maturity		Grain filling period (days)		Plant height (cm)	
	2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019
σ_p^2	16.86**	18.84**	13.39**	8.64**	7.77**	6.97*	174.47**	323.05**
Ve	1.66	7.93	1.94	4.01	2.48	4.46	14.05	13.82
σ_g^2	15.2	10.91	11.46	4.63	5.29	2.51	160.42	309.22
h^2	90.13	57.91	85.54	53.58	68.04	36.03	91.95	95.72
Heterosis (BP)	2.9**	2.62**	1.78**	0.56	2.33**	-2.11**	7.33**	8.33**
Potence ratio	-0.15	0.55	0.0	-0.31	-0.77	3.06	0.06	0.5
Inbreeding depression	-5.1	1.12	-1.93	-0.62	4.11	-4.78	9.01	-2.33
PCV%	4.6	4.19	2.77	1.92	6.52	5.36	16.81	16.73
GCV%	4.37	3.19	2.56	1.41	5.38	3.22	16.12	16.37
Parameter	No. of spikes plant^{-1}		No. of kernels spike^{-1}		100-kernel weight (g)		Grain yield plant^{-1} (g)	
	2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019
σ_p^2	11.94**	34.21**	122.61**	186.92**	1.13**	1.05**	21.85**	210.34**
Ve	1.25	12.73	12.74	13.65	0.15	0.14	8.1	31.38
σ_g^2	10.69	21.48	109.87	173.27	0.98	0.91	13.74	178.97
h^2	89.51	62.79	89.61	92.7	86.7	86.59	62.91	85.08
Heterosis (BP)	23.44**	31.67**	15.18**	10**	1.27**	5.03**	23.38**	40.89**
Potence ratio	-0.55	-0.4	-1.15	-0.48	-0.48	-0.01	-0.12	1.47
Inbreeding depression	43.9**	13.91*	0.52	1.05	15.28**	23.25**	32.64**	17.44
PCV%	64.72	55.09	13.5	16.75	34.52	32.43	36.83	63.00
GCV%	61.23	43.65	12.78	16.12	32.14	30.18	29.21	58.11

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**

Table 3. Base population mean (X_0), mean of the selected plants (X_s), selection differential (S), expected response to selection (RS), expected response to selection expressed as percentage of the base population mean (%RS), and predicted genetic gain (PGG) for the studied characters of the parents and their F_2 derived from Giza 171 x Sids 12.

Parameter	Days to heading		Days to maturity		Grain filling period (days)		Plant height (cm)	
	2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019
X_0	89.27	103.48	132.02	152.72	42.74	49.25	78.56	107.44
X_s	81.95	96.85	127.45	147.95	38.2	44.55	58.58	77.25
S	-7.32	-6.63	-4.57	-4.77	-4.54	-4.7	-19.98	-30.19
RS	-6.6	-3.84	-3.91	-2.56	-3.09	-1.69	-18.37	-28.9
RS%	-7.39	-3.71	-2.96	-1.67	-7.23	-3.44	-23.39	-26.9
PGG	82.67	99.64	128.11	150.17	39.65	47.55	60.18	78.54
Parameter	No. of spikes plant^{-1}		No. of kernels spke^{-1}		100-kernel weight (g)		Grain yield plant^{-1} (g)	
	2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019
X_0	5.34	10.62	81.99	81.64	3.08	3.16	12.69	23.02
X_s	11.80	22	100.15	94.35	5.29	4.8	22.39	51.85
S	6.46	11.38	18.16	12.71	2.21	1.64	9.7	28.83
RS	5.78	7.15	16.27	11.79	1.91	1.42	6.1	24.53
RS%	108.35	67.31	19.84	14.44	62.11	44.85	48.09	106.56
PGG	11.12	17.76	98.26	93.42	4.99	4.58	18.79	47.55

Inheritance of the F_3 families

Agronomic Performance of the 100 families

The variance analysis of the agronomic characters for F_3 families and their two parents are illustrated in Table 4. Highly significant variations were recorded among F_3 families for all studied characters, showing sufficient genetic variability and enable to estimating various genetic parameters. Similar findings were recorded by Ghuttai *et al.* (2015) and Kumar *et al.* (2017), Darwish *et al.*, (2018a).

Descriptive statistics and variance parameters estimated for the studied traits of the 100 F_3 families and Giza 171 and Sids 12 during the 2018/2019 season are showed in Table 5. Compared to Giza 171, Sids 12 had lower values for heading and maturity, plant height, grain filling rate, No. of spikes m^{-2} and grain yield, while had higher values for grain filling period, No. of kernels spike^{-1}, 100-kernel weight. The minimum and maximum values of the F_3 families transgress the two parents for all studied characters, indicating the presence of transgressive segregation and enable to select the best families with the improved characters.

Genotypic variance was higher than environmental variance only for days to heading, grain filling rate, plant height, No. of spikes m^{-2} and grain yield m^{-2}, pointing to the possibility of improving for the studied characters. While, the environmental variances were higher than the corresponding genotypic ones for days to maturity, grain filling period, No. of kernels spikes^{-1} and 100-kernel weight, suggesting larger role of the environments in inheritance of these characters.

Table 4. Mean squares of the studied characters for the 100 F_3 families and their two parents Giza 171 and Sids 12 as checks.

SOV	df	Days to heading	Days to maturity	Grain filling period (days)	Grain filling rate (g days^{-1} m^{-2})	Plant height (cm)	No. of spikes plant^{-1}	No. of kernels spke^{-1}	1000-kernel weight (g)	Grain yield (kg m^{-2})
Replications	2	122.18**	97.82**	60.19**	4.75	81.62*	17609.42*	1470.24**	1.81**	0.002
Genotypes	101	33.93**	11.71**	13.42**	53.3**	434.72**	18545.21**	232.34**	0.8**	0.123**
Families	99	34.18**	11.57**	13.68**	51.94**	440.02**	18196.2**	222.62**	0.81**	0.1202**
Checks	1	42.67	37.5	0.17	34.67**	266.67	33750	433.5	0.48	0.076
Families vs Checks	1	0.97	0.0001	0.99	205.88	78.37	37892.16	993.1**	0.46	0.467**
Error	202	5.35	4.70	5.71	3.65	25.92	4221.50	79.41	0.22	0.01
Total	305									
CV		2.23	1.40	4.98	9.84	4.63	13.44	12.61	13.53	9.57

*** and ** significant at 0.05 and 0.01 levels of probability, respectively**

Table 5. Descriptive statistics and variance parameters estimated for the studied traits of the 100 F_3 families and their two parents during the 2018/2019 season.

Family/parent	Days to heading	Days to maturity	Grain filling period (days)	Grain filling rate (g days^{-1} m^{-2})	Plant height (cm)	No. of spikes plant^{-1}	No. of kernels spke^{-1}	1000-kernel weight (g)	Grain yield (kg m^{-2})
Families' minimum	97.00	146.33	43.67	4.51	73.33	200.00	46.07	2.36	0.231
Families' maximum	109.67	157.00	53.67	21.44	143.33	509.33	89.27	5.25	1.072
Families' mean	103.59	152.17	48.58	11.11	106.98	328.07	66.17	4.06	0.537
Giza171	106.67	154.67	48.00	19.43	110.00	483.33	70.67	3.50	0.932
Sids12	101.33	149.67	48.33	14.62	96.67	333.33	87.67	4.07	0.707
				Genetic parameters					
σ_p^2	14.94	6.96	8.35	19.74	163.93	8870.60	126.65	0.42	0.05
σ_g^2	9.58	2.26	2.64	16.08	138.01	4649.10	47.24	0.19	0.04
σ_e^2	5.35	4.70	5.71	3.65	25.92	4221.50	79.41	0.22	0.01
h^2	64.15	32.52	31.63	81.49	84.19	52.41	37.30	46.35	82.45
GA	4.09	1.01	1.059	6.73	20.37	73.62	5.28	0.42	0.33
GA%	3.95	0.66	2.18	60.62	19.04	22.44	7.98	10.34	61.08

σ^2_p, Phenotypic variance; σ^2_g, genotypic variance; σ^2_e, environmental variance, h^2, broad-sense heritability; GA, genetic advance; GA%, genetic advance as percentage of F_3 mean.

High heritability in the broad sense was estimated for days to heading and maturity, grain filling rate, plant height, No. of kernels spike^{-1}and grain yield m^{-2}, indicating that phenotypic variance is a good index of genotypic one and selection for these characters is also easy. On the other hand, grain filling period, No. of spikes m^{-2} and 1000-kernel weight had medium estimates of broad sense heritability, suggesting that these characters have quantitatively inherited and controlled by many genes.

The lowest values of genetic advance in the F_4 will be predicted for grain filling period with 1.06 day equal to 0.66% of all families' mean, followed by days to heading with 4.01 days equal to 2.18% of all families' mean, then days to maturity with 1.01 day equal to 3.95 % of all families' mean. On the other hand, the highest values will be predicted for grain yield with 0.3 Kg m^{-2} equal to 61.08 % of all families' mean, followed by grain filling rate with 6.73 g days^{-1} m^{-2} equal to 60.62% of all families' mean. Whereas, plant height with 20.37 cm equal to 19.04 % of all families' mean, then No. of spikes m^{-2} with 73.62 spikes m^{-2} equal to 22.44% of all families' mean, after that No. of kernels spike^{-1} with 5.28 kernels spike^{-1} equal to 7.98% of all families' mean, and later 100-kernel weight with 0.42 g equal to 10.34% of all families' mean will be expected to be improved in medium level.

Estimation of variance components and genetic parameters in the segregation generations has been studied by many researchers in order to predict the genetic advance and select the promising genotypes. In many cases, the heritabilities in narrow and broad senses were medium to high (Kumar *et al.*, 2017; Saleh, 2017; Darwish *et al.*, 2018a; Fellahi *et al.*, 2018 and Gaur, 2019).

The correlations among the studied characters are indicated in Table 6. Positive and significant correlations were detected between days to heading with days to maturity; grain filling rate with each of plant height and, No. spikes with No. kernels spike^{-1}; No. of spikes with No. of kernels spike^{-1}; 100-kernel weight with each of grain filling rate, plant weight, No of spikes and No. of kernels spike^{-1}; and later grain yield with each of grain filling rate, plant height, No. of spikes m^{-2}, No. of kernels spike^{-1} and 100-kernel weight. On the other hand, negative and significant correlations were observed between days to heading and each of grain filling period, plant height and 100-kernels weight; and days to maturity with each of grain filling period, plant height and100-kernels weight. In addition, days to heading and maturity was positively and insignificantly correlated with yield, indicating that late families out yielded the early ones. The most impact on grain yield were observed for grain filling rate, followed by No. of spikes m^{-2}, then 100-kernel weight, later the No. of kernel spike^{-1} as these characters had the highest correlation coefficients, respectively. The negative correlation of grain yield with grain filling period indicates that the high-yielding genotypes have fill their grain rapidly (Tadesse *et al.,* 2015; Ogbonnaya *et al.,* 2017 and Tadesse *et al.,* 2019). The number of spikes per unit area is an important yield component that has contributed to wheat genetic gains and adaptation during the 20th century (Sanchez-Garcia *et al.,* 2012 and 2013).

Table 6. Simple correlation among the studied characters in the 100 F_3 families.

Characters	DH	DM	GP	GR	PH	SM	KS	KW	GY
DH		0.81**	-0.84**	0.11	-0.37**	0.09	-0.03	-0.2*	0.02
DM			-0.36**	0.06	-0.57**	0.03	0.07	-0.31**	0.016
GP				-0.12	0.06	-0.11	0.11	0.03	-0.013
GR					0.28**	0.78**	0.45**	0.49**	0.99**
PH						0.17	0.07	0.4**	0.29**
SM							0.25*	0.31**	0.77**
KS								0.22*	0.48**
KW									0.5**

*** and ** significant at 0.05 and 0.01 levels of probability, respectively**

DH =Days to heading, DM =Days to maturity, GP =Grain filling period (days), GR = Grain filling period (g days^{-1} m^{-2}) , PH =Plant height (cm), SM = No. of spikes m^{-2}, KS = No. of kernels spke^{-1}, KW =1000-kernel weight (g), GY = Grain yield (kg m^{-2}).

Promotion of the superior families in F_3 to F_4 generation

The selection procedure takes into consideration the resistance to the three rusts first, then the grain yield potentiality secondly, later that the appropriate plant height. To select the best families in the F_3 population to advance to as F_4 families, the reaction to yellow, leaf and stem rusts, plant height and grain yield for each family were considered (Table 7).

The selection process based on selecting the families with grain yield around the higher parent (Gemmeiza 9 and Sids 1) or higher, medium height (90-105 cm) and resistant to the three rusts. From 100 evaluated families, thirteen families (13 %) were selected.

The means of F_3 families were compared to the two parents as checks using LSD, and as a result, 31 families were not significantly different from Sids 12. Of the thirteen high yielding families, 13 were resistant to the three rusts and have appropriate height, therefore, these families were selected. According to the previous study of Farhat and Mohammed (2018), in which the hybrid of Giza 171 and Sids 12 was promising regarding grain quality, therefore, these families were used to study grain quality using the bulk of all plants within each family. The best families for the grain quality were No. 12, 33 and 98 that gave the highest protein contents with15.2, 16.8 and 15.5 % at the same time had high relative hydration with 187.20, 180.44 and 169.26 %. Following that, the families No. 76 and 80 values of dry gluten a little less than Sids 12 with high relative hydration. These five families, although slightly fewer than the other selected families in grain yield, are promising in obtaining lines after that resistant to the three rusts with good grain quality. Similar selection process was also performed by Ragab (2010); Laala *et al.* (2017) and Darwish *et al.* (2018b).

Table 7. Means of the selected family's and the two parents as checks for the agronomic and grain quality characters.

Family	Days to heading	Days to maturity	Grain filling period (days)	Grain filling period (g days^{-1} m^{-2})	Plant height (cm)	No. of spikes plant^{-1}	No. of kernels spke^{-1}	1000-kernel weight (g)	Grain yield (kg m^{-2})	Wet gluten %	Dry gluten %	Relative hydration %	Protein %
5	106.3	153.3	47.0	13.9	120.0	382.0	64.5	3.99	0.651	27.9	10.4	169.16	14.5
7	105.7	152.7	47.0	17.3	105.0	429.3	66.5	4.01	0.811	23.7	10.7	124.11	14.8
8	102.3	151.7	49.3	18.0	115.0	397.3	83.3	4.64	0.884	28.8	10.7	170.32	13.4
15	100.0	149.3	49.3	16.8	110.0	389.3	89.3	4.51	0.823	26.4	9.3	182.97	11.8
16	100.7	150.3	49.7	15.9	111.7	360.0	83.8	4.91	0.784	18.4	7.0	163.24	13.0
21	102.0	151.3	49.3	13.5	120.0	368.0	61.6	3.97	0.667	26.8	9.3	187.20	15.2
33	102.0	150.0	48.0	14.3	113.3	509.3	75.3	4.46	0.687	23.7	8.5	180.44	16.8
39	108.3	156.0	47.7	18.1	110.0	472.0	68.3	4.09	0.859	23.2	8.4	176.19	11.5
43	103.3	151.3	48.0	15.6	113.3	452.0	79.1	3.83	0.753	19.9	7.7	160.26	13.2
52	109.7	157.0	47.3	19.1	100.0	426.0	64.8	4.23	0.904	29.3	9.9	197.50	11.7
76	104.3	151.7	47.3	13.2	103.3	453.3	51.3	4.98	0.624	32.5	12.3	164.98	13.0
80	97.3	148.7	51.3	13.7	116.7	400.0	67.3	3.74	0.705	33.1	12.1	172.29	14.0
98	105.0	152.3	47.3	14.9	121.7	364.7	72.5	4.11	0.705	31.2	11.6	169.26	15.5
Giza171	106.7	154.7	48.0	19.4	110.0	483.3	70.7	3.50	0.932	29.3	12.9	126.98	12.0
Sids12	101.3	149.7	48.3	14.6	96.7	333.3	87.7	4.07	0.707	31.6	14.0	126.68	13.3
Mean of selected families	103.67	152.00	48.33	15.88	111.11	414.67	72.39	4.20	0.77	27.06	10.32	164.77	13.59
$LSD_{0.05}$	3.29	3.90	3.90	2.86	8.67	109.34	7.43	0.69	0.13	1.92	1.13	23.75	0.89

Inheritance nature of resistance to rusts diseases in F_2 and F_3

Distribution and chi square (χ^2) estimates of 200 plants of F_2 and 100 families of F_3 populations for the three rusts' reaction under field conditions in season 2018/2019 are showed in Table 8. For yellow rust, the parent Giza 171 was resistant, while the parent Sids 12 was susceptible and the F_1 showed the dominance of resistance over the susceptibility. Meanwhile, the F_2 and F_3 generations segregated in a 13 resistant : 1 susceptible and a 8 homozygous resistant : 7 segregating : 1 homozygous susceptible ratio, respectively, suggesting resistance is controlled by two dominant genes.

Regarding leaf rust, the parent Sids 12 was resistant, while the parent Giza 171 was susceptible and the resistance was dominance over the susceptibility in F_1. In addition, the segregation in F_2 and F_3 was fit to the 13 (resistant) : 3 (susceptible) and 8 homozygous resistant : 7 segregating : 1 homozygous susceptible ratio, respectively, therefore, the difference between Sids 12 and Giza 171 was under control of two dominant genes.

Both Giza 171 and Sids 12 was susceptible for stem rust, while the F_1 revealed the dominance of susceptibility over the resistance reaction. Over the above, F_2 and F_3 generations segregated and had the fit to 9 (resistant) : 7 (susceptible) and 8 homozygous resistant : 7 segregating : 1 homozygous susceptible ratio, respectively, suggesting that the difference between the two parents was controlled by two complementary dominant genes.

There are studies demonstrated the response of Giza 171 and Sids 12 and the inheritance of rust resistance in F_2 and F_3 generations and reported that yellow, leaf and stem rusts were controlled by one or two genes in complimentary dominance or independent in their expressions (Ragab, 2010; Youssef *et al.*, 2012; Ali, 2017; Darwish *et al.*, 2018a; Shahin *et al.*, 2018 and El-Orabey *et al* ., 2019).

Table 8. Segregation and chi square (χ2) analysis of F_2 plants (200 plants), F_3 (100 families) from Giza 171 x Sids 12 cross in addition to the two parents and their F_1 reaction to yellow, leaf and stem rusts under field condition.

Rust	Parents/ generations	No. of resistant plants (or homogenous resistant families)	No. of seg000000 regant families	No. of susceptible plants (or homogenous susceptible families)	% of resistant plants (or homogenous resistant families)	% of segregant families	% of susceptible plants (or homogenous susceptible families)	Expected ratio	χ2	P value
Yellow rust	Giza 171	50	-	0	100.0	-	0.0			
	Sids 12	0	-	50	0.0	-	100.0			
	F_1	50	-	0	100.0	-	0.0			
	F_2	166	-	34	82.86	-	17.14	13:3	0.30	0.59
	F_3	41	49	10	41.00	49.00	10.00	7 : 8 : 1	2.44	0.29
Leaf rust	Giza 171	0	-	50	0.0	-	100			
	Sids 12	50	-	0	100	-	0			
	F_1	50	-	0	100	-	0			
	F_2	171	-	29	85.71	-	14.29	13:3	2.29	0.13
	F_3	51	41	8	51.00	41.00	8.00	7 : 8 : 1	3.31	0.19
Stem rust	Giza 171	0	-	50	0.0	-	100			
	Sids 12	0	-	50	0.0	-	100			
	F_1	50	-	-	0.0	-	100			
	F_2	125	-	75	62.29	-	37.71	9:7	2.59	0.11
	F_3	9	56	35	9	56	35	1 : 8 : 7	3.68	0.16

CONCLUSION

The hybrid Giza 171 x Sids 12 is a promising one for breeder to select to many purposes like grain yield, rust resistance and grain quality. The findings of this study confirmed that by many descriptive and genetic parameters. The ranges of the F_2 and F_3 populations went out the means of its parents for the studied characters. The genetic variance exceeded the corresponding environmental variances for most studied characters. The most important characters for selection to high yield in bread wheat under this study are grain filling rate, followed by No. of spikes m^{-2}, then 100-kernel weight, later the No. of kernels $spike^{-1}$. The resistance of yellow and leaf rusts was controlled by two dominant genes and stem rust was controlled by two complementary dominant genes. Thirteen promising families were high yielding, resistant to the three rusts and have appropriate height were selected to promote to the next advanced segregating generations and five of them were preferable for grain quality of bread wheat.

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الانتخاب للمحصول والمقاومة للأصداء وصفات الجودة في الأجيال المبكرة من الهجين جيزة 171× سدس 12 من قمح الخبز

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تمت دراسة الأجيال الثاني والثالث الناتجة من الهجين جيزة 171/سدس 12 من موسم 2016 وحتى موسم 2019 في محطة البحوث الزراعية في سخا لدراسة وراثة بعض الصفات المحصولية ومقاومة أمراض الصدأ وانتخاب عائلات جديدة مبشرة في محصول وجودة الحبوب. كانت الاختلافات الوراثية بين الأبوين كافية لحساب المعالم الوراثية. وكان الصنف جيزة 171 أفضل بالنسبة لمحصول الحبوب ومكوناته، في حين كان سدس 12 أفضل لصفات التبكير. وقد تعد مدى الصفات للجيلين الثاني والثالث متوسطات الأبوين. وقد زاد التباين الوراثي عن التباين البيئي لمعظم الصفات المدروسة. وأظهرت جميع الصفات المدروسة قيمًا متوسطة إلى عالية من المكافئ الوراثي بالمعنى الواسع في الجيلين. وكانت أفضل الصفات في الاستجابة للانتخاب في الجيل الثاني هي عدد السنابل للنبات وعدد حبوب السنبلة، في حين كانت عدد الأيام حتى النضج الأقل استجابة للانتخاب. وقد ظهرت بين عائلات الثالث اختلافات وراثية كبيرة لجميع الصفات المدروسة. وقد أشارت معاملات الارتباط إلى أن صفات معدل امتلاء الحبوب، ثم عدد السنابل م2، ثم وزن الحبوب، وأخيرا عدد حبوب السنبلة ذات التأثير الأكبر محصول الحبوب في عائلات الجيل الثالث. وأظهرت النتائج أن مقاومة الصدأ الأصفر وصدأ الأوراق كانت محكومة بجينين سائدين بينما بالنسبة لصدأ الساق كان واقعا تحت تحكم جينين سائدين مكملين. نتج عن الانتخاب ثلاث عشرة عائلة مبشرة ذات محصول حبوب مرتفع ومقاومة للأصداء الثلاثة ومناسبة في الطول يمكن الدفع بها إلى الأجيال المتقدمة التالية، منها خمس عائلات ذات صفات جودة حبوب مبشرة.