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COMBINING ABILITY FOR YIELD AND ITS COMPONENTS IN BREAD WHEAT UNDER DIFFERENT NITROGEN RATES BY LINE × TESTER ANALYSIS

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ABSTRACT: Fourteen bread wheat varieties were crossed in a line x testers analysis (10 lines and four testers) to obtain 40 F_1's hybrids to evaluate combining ability and genetic components in F_1 hybrids under normal (80 kg N/fed) and low (40 kg N/fed) levels of nitrogen fertilization. Results cleared that genotypes, parents and crosses mean squares were found to be highly significant for all traits studied and also, their interactions with the two levels of nitrogen fertilization. Parent *vs.* crosses mean squares were found to be highly significant for all traits studied except, number of grains per spike under low-N. Lines, testers and line x testers mean squares and their interaction with nitrogen levels were highly significant for all traits studied. The parental line Gemmeiza 11 (L3) was a good combiner under low-N for all traits studied except, 1000-grain weight. The parental line Misr 1 (L6) for 1000-grain weight and grain yield per plant. The parental line Gemmeiza 12 (L10) for number of spikes per plant, 1000-grain weight and grain yield per plant. The tester Sids 12 (T2) was a good combiner number of grains per spike, 1000-grain weight and grain yield per plant and the tester Giza 168 (T4) for number of spikes per plant, 1000-grain weight and grain yield per plant under low-N. The desirable SCA effects were detected by twelve hybrids. The GCA/SCA ratio were less than unity at both levels of fertilization for all traits studied, indicating that non-additive gene effects in controlling the inheritance of all the traits studied.

Key words: Wheat, Combining ability effects, Line × tester analysis and Nitrogen fertilization.

INTRODUCTION

Bread wheat is one of the most important crops in Egypt. The local production covers less than half of the local consumption. Increasing wheat productivity is a nation target in Egypt to reduce the gap between wheat production and consumption. The production of wheat can be increased by increasing the agricultural area or by increasing yield productivity per unit area. Currently, it is difficult to increase the agricultural area of wheat due to competition with other winter crops as well as restricted reclaimed lands and water shortage. Therefor, the alternative strategic solution is use high yielding cultivars characterized by tolerance against environmental stresses, especially soil nitrogen deficit, which affect the production of wheat. Applying nitrogen fertilization is the most important cultural practices to maximize wheat productivity through improving vegetative growth and enhancing kernel set. The needs of new wheat genotypes to high doses of nitrogen fertilizer became important to express full yield potential. To be crease the cultivation costs the breeders should develop new wheat genotypes with high tolerance to nitrogen deficiency to avoid the effect of nitrogen to the land and atmosphere pollution and other components of the ecosystem (Bouwman *et al*., 2002). To establish an effective breeding program, enough information about the components of genetic variance and their interactions with nitrogen applications must know by the breeder. For effective improvement in yield of wheat, one can use combining ability analysis to test the performance of selected parents in different cross combinations and can characterize the nature and magnitude of gene effects in the expression of

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various yield contributing traits. such information will lead to the selection of superior parental lines and isolation of potential cross combinations for the use in plant breeding programs. Keeping the above in view, the present line x tester analysis was planned to estimate general and specific combining ability effects to identify better parents as well as superior cross combinations for further improvement in wheat. Aim of the study, (1) to identify good combiner parents under low level of nitrogen to be use in future in breed programs. (2) to determine general combining ability (GCA) as well as specific combining ability (SCA) for genotypes under two levels of nitrogen fertilization. (3) to estimate genetic components *i.e* heritability, additive and dominance under two levels of nitrogen fertilization.

MARTIAL AND METHODS

This study was carried out at the Experimental Farm of Gemmeiza Agriculture Research Station, Egypt during the two successive growing seasons 2013/ 2014 and 2014/ 2015. In the first season (2013-14), ten lines (used as females) were crossed by the four testers (used as males) were intercrossed (by hand emasculation and pollination techniques) to produce 40 F_1 hybrids by line x tester design. Name, code and pedigree of fourteen bread wheat varieties are listed in Table 1.

Table 1: Name, code and pedigree of the parental wheat genotypes used in the study.

Name	Code	Pedigree
Lines		
Gemmeiza 7	L1	CMH74.630/5X//SERI82/3/AGENT CGM4611-2GM-3GM-1GM-0GM
Gemmeiza 10	L2	MAYA74"S"/ON//1160-47/3/BB/GLL/4/CHAT"S"/5/CROW"S".
Gemmeiza 11	L3	BOW"S"/KVZ"S"//7C/SERI82/3/GIZA168/SAKHA61 GM7892-2GM-1GM-2GM-1GM-0GM
Sakha 93	L4	Sakha 92TR 810328
Sakha 94	L5	OPATA/RAYON//KAUZ.CMBW90Y3180-0TOM-3Y-010M-010Y-10M-015Y-0Y-0AP-0S.
Misr 1	L6	OASIS/SKAUZ//4*BCN/3/2*PASTOR. CMSS00Y01881T-050M-030Y-030M-030WGY-33M-0Y-0S SKAUZ / BAV92
Misr 2	L7	SKAUZ/BAV 92 CMSS96M03611S-1M-010SY-010M-010SY-8M-0Y-0S
Sids 13	L8	ALMAZ.19=KAUZ"S"// TSI/ SNB"S"
Sids 14	L9	KAUZ"S"//TSI/SNB"S". ICW94-0375-4AP-2AP-030AP-OAPS-3AP.
Gemmeiza12	L10	OTUS/3/SARA/THB//VEE CMSS97Y00227S-5y-010M-010Y-010M-2Y-1M-0Y-OGM
Testers		
Gemmeiza 9	T1	ALD "S" /HUAC // CMH 74 A. 630/SX CGM 4583 - 5 GM - 1GM - OGM
Sids 12	T2	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.
Shandaweel1	T3	SITE//MO/4/NAC/TH.AC//3*PVN/3/MIRLO/BUC. CMSS93B00567S-72Y-010M-010Y-010M-0HTY-0SH.
Giza 168	T4	MRL/ BUC// SERI CM 93046-8M-0Y-0M-2Y-0B-0GZ

In second season (2014-15), two separate and adjacent field experiments representing two different nitrogen fertilization levels; 80 kg N/fed (normal level) and 40 kg N/fed (low level). Nitrogen fertilizer was added in the form of Urea (46.5% N). The amount of each dose was divided into two equal doses; the first dose was immediately applied before the first irrigation, while the second dose was applied before the second irrigation. Each experiment was included the 40 F_1 hybrids and their respective parents (ten lines and four testers) were sown in 20th November. Each experiment was laid in a Randomized Complete Block Design with three replications in rows with 3 m long and 30 cm between rows and 20 cm between plants within rows. Other cultural practices were following as usually recommended for the ordinary wheat fields in the region of the experiment. Before sowing, soil samples were randomly collected from the experimental site at two depths (0–30 and 30-60 cm) to estimate the mechanical and chemical properties of soil. The analysis was done as the methods outlined by Jackson (1973) and Page *et al.* (1982). Soil characterization of the experimental site during 2014/2015 seasons are listed in Table 2.

Measurements

Ten individual guarded plants taken at random of parent varieties and their F_1 hybrids from each plot for recording observations on different traits *i.e.* number of spikes per plant, number of grains per spike, 1000-grain weight (g) and grain yield per plant (g).

Table (2): Physical and chemical characters of soil.

Soil properties	2014/2015 Season	
	0-30 cm	30-60 cm
Particle size distribution		
Coarse sand	5.69	7.05
Fine sand	11.61	12.11
Silt	29.07	31.06
Clay	53.63	49.78
Texture class	Clay	Clay
pH	7.68	8.02
EC (dS/m)	0.73	0.86
OM (%)	1.82	1.77
Soluble cations (meq/L)		
Ca^{2+}	1.90	2.10
Mg^{2+}	1.75	2.05
Na^{+}	3.20	4.07
K^{+}	0.25	0.28
Soluble anions (meq/L)		
Cl^{-}	2.40	2.96
HCO_3^{-}	3.18	3.88
SO_2^{4-}	1.52	1.66
Available elements		
Available N (ppm)	42.89	41.01
Available P (ppm)	7.99	8.11
Available K (ppm)	394	382

pH: Soil reaction (measured in 1:2.5, soil: distilled water suspension), EC: electrical conductivity of soil saturated paste extract, OM: Organic matter content

Statistical analysis

Data for each trait depicting significant difference were further analyzed for line x tester according by Kempthorne (1957). Analysis of variance of RCBD was performed as outlined by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Analysis of variance

Mean squares for grain yield and some agronomic traits of the 54 wheat genotypes at each nitrogen fertilization level and combined analysis are presented in Table (3). The results showed that mean squares due to nitrogen fertilization levels for all traits were significant, suggesting that these traits are influenced by different nitrogen fertilization levels. The mean squares due to genotypes and their interaction with nitrogen levels were significant for all traits studied, reflecting that the performance of genotypes was inconsistent in their responses to nitrogen treatments. The mean squares due to parents, crosses and their interaction with nitrogen fertilizer levels were highly significant for all traits studied. Mean squares due to parents *vs.* crosses were significant for all traits studied at both nitrogen levels except, number of grains per spike under low nitrogen fertilizer level, indicating that average heterosis over all crosses was pronounced for the traits studied under such environments. Moreover, interaction of parents *vs.* crosses with nitrogen levels was significant for most traits studied, suggesting that heterosis differed from nitrogen level to another. The mean squares due to lines, testers and line × testers were highly significant for all traits studied indicating that both lines and testers were different from one to another in top crosses. Mean squares due to the interaction between lines, testers and line × tester with nitrogen fertilizer levels were highly significant for all traits studied. These results are in line with these of Koumber (2007), Akbar *et al.* (2009), Abdel Nour *et al.* (2011), Fellahi *et al.* (2013), Al-Naggar *et al.* (2015), El-Nahas *et al.* (2021) and Chawan *et al.* (2022).

Table 3: Mean squares for all traits studied at line x tester crosses under normal nitrogen (N), low nitrogen (L) and their combined analysis.

S.O.V.	df		No. of spikes per plant			No. of grains per spike		
	N	Comb.	N	L	Comb.	N	L	Comb.
N		1			1090.43**			9794.39**
Rep / N	2	4	0.06	0.13*	0.10*	1.29	16.39*	8.84
Genotypes	53	53	4.84**	2.90**	3.94**	88.71**	42.56**	92.06**
parents	13	13	10.55**	6.45**	7.46**	169.70**	72.72**	196.70**
Crosses	39	39	2.94**	1.50**	2.49**	57.27**	33.48**	57.03**
P vs C	1	1	4.46**	11.19**	14.89**	261.63**	4.69	98.13**
Lines	9	9	9.53**	3.21**	7.03**	14.86**	72.65**	53.44**
Testers	3	3	4.15**	4.45**	5.56**	404.49**	68.14**	371.59**
Line × Tester	27	27	0.61**	0.60**	0.63**	32.83**	16.57**	23.27**
Genotype × N		53			3.79**			39.21**
Crosses × N		39			1.96**			33.73**
Lines × N		9			5.71**			34.07**
Testers × N		3			3.04**			101.04**
Line × Tester × N		27			0.59**			26.13**
Parents × N		13			9.54**			45.72**
P vs C × N		1			0.76**			168.19**
Error	106	212	0.03	0.03	0.03	2.92	4.42	3.67

* and ** Significant at 0.05 and 0.01 probability levels, respectively.

Table 3: Cont.

S.O.V.	df		1000-grain weight (g)			Grain yield per plant (g)		
	N	Comb.	N	L	Comb.	N	L	Comb.
N		1			1779.43**			3894.69**
Rep / N	2	4	0.03	0.15	0.09	1.13	0.00	0.57
Genotypes	53	53	45.49**	46.92**	82.54**	30.49**	22.86**	30.35**
parents	13	13	42.24**	46.87**	87.33**	43.30**	26.63**	43.98**
Crosses	39	39	42.28**	44.76**	74.34**	26.14**	22.13**	25.90**
P vs C	1	1	212.86**	131.83**	339.86**	33.61**	2.25*	26.62**
Lines	9	9	68.70**	74.61**	132.74**	20.07**	39.17**	30.91**
Testers	3	3	20.77**	55.16**	58.88**	178.15**	47.24**	112.01**
Line × Tester	27	27	35.87**	33.65**	56.59**	11.27**	13.65**	14.67**
Genotype × N		53			9.87**			22.99**
Crosses × N		39			12.70**			22.36**
Lines × N		9			10.57**			28.33**
Testers × N		3			17.05**			113.39**
Line × Tester × N		27			12.93**			10.26**
Parents × N		13			1.78**			25.95**
P vs C × N		1			4.83**			9.24**
Error	106	212	0.07	0.11	0.09	0.47	0.38	0.43

* and ** Significant at 0.05 and 0.01 probability levels, respectively.

Mean performance

Mean performance for all genotypes studied under two levels of nitrogen fertilization and combined analysis are presented in Table 4.

For number of spikes per plant, the highest mean value for line were 15.56 spike and 12.39 spike by Sids 13 (L8) under normal nitrogen and combined. While, 9.80 spike by Sakha 94 (L5) under low nitrogen. Highly value of mean for testers was recorded by Shandaweel 1 (T3) under two treatment and their combined. Mean performance for hybrids under normal nitrogen ranged from 10.87 spike for Gemmeiza 12 (L10) × Sids 12 (T2) to 14.55 spike for Sids 13 (L8) × Gemmeiza 9 (T1). Under low nitrogen, mean value ranged from 7.34 spike for Gemmeiza 7 (L1) × Gemmeiza 9 (T1) to 10.57 spike for Misr 2 (L7) × Giza 168 (T4). Meanwhile, 9.73 spike for Sakha 93 (L4) × Sids 12 (T2) to 12.09 spike for Misr 2 (L7) × Giza 168 (T4) under combined data.

For number of grains per spike, the average of lines were over 80 grains and 70 grains per spike and over 3g and 2g for weight per spike under normal nitrogen and low nitrogen, respectively. The best parental line was Gemmeiza 11 (L3) under the two treatment and their combined. The highest mean value for tester was Sids 12 (T2) under normal nitrogen and combined data and Shandaweel (T3) under low nitrogen.

Mean performance for F_1 hybrids were ranged from 73.97 grains for Gemmeiza 10 (L2) × Gemmeiza 9 (T1) to 90.00 grains for Gemmeiza 7 (L1) × Gemmeiza 9 (T1) under normal nitrogen. Under low nitrogen, mean hybrids for number of grains per spike ranged from 63.86 grains for Misr 1 (L6) × Gemmeiza 9 (T1) to 82.56 grains for Gemmeiza 11 (L3) × Sids 12 (T2). The lowest mean value for hybrids was 70.87 grains that recorded in two hybrids Sakha 94 (L5) × Gemmeiza 9 (T1) and Misr 1 (L6) × Gemmeiza 9 (T1), but the highest mean value was 85.31 grains that founded by Gemmeiza 11 (L3) × Sids 12 (T2) under combined analysis.

Table 4: Genotype mean performance at normal nitrogen (N) and low nitrogen (L) and their combined for all traits studied.

Genotype	No. of spikes per plant			No. of grains per spike		
	N	L	Comb.	N	L	Comb.
Lines						
L1	13.69	6.36	10.03	76.51	75.48	76.00
L2	12.72	7.45	10.08	79.49	65.19	72.34
L3	10.48	8.67	9.58	88.55	82.50	85.53
L4	12.00	5.37	8.69	69.81	66.71	68.26
L5	11.33	9.80	10.56	73.53	71.48	72.50
L6	12.44	6.71	9.58	72.02	66.61	69.31
L7	14.33	9.48	11.91	86.66	74.14	80.40
L8	15.56	9.21	12.39	78.70	71.75	75.22
L9	15.47	8.44	11.95	75.38	67.08	71.23
L10	11.49	9.70	10.60	78.21	75.10	76.66
Average lines	12.31	8.48	10.39	80.78	72.22	76.50
Testers						
T1	10.53	8.70	9.62	79.70	68.46	74.08
T2	9.45	8.82	9.14	95.10	75.96	85.53
T3	12.08	10.34	11.21	87.76	76.15	81.96
T4	10.73	9.58	10.16	89.48	74.45	81.97
Average testers	12.59	8.92	10.75	82.93	71.93	77.43
Hybrids						
L1 × T1	13.22	7.34	10.28	80.19	75.54	77.87
L1 × T2	12.53	8.44	10.49	90.00	70.09	80.04
L1 × T3	13.14	8.91	11.02	84.62	74.04	79.33
L1 × T4	12.11	8.69	10.40	83.33	71.35	77.34
L2 × T1	12.75	8.87	10.81	73.97	71.52	72.75
L2 × T2	11.30	8.55	9.93	89.66	69.89	79.78
L2 × T3	11.91	9.73	10.82	87.25	69.19	78.22
L2 × T4	12.29	9.16	10.72	89.42	69.19	79.31
L3 × T1	10.93	9.27	10.10	83.74	75.96	79.85
L3 × T2	11.23	9.37	10.30	88.06	82.56	85.31
L3 × T3	12.44	9.54	10.99	81.18	76.51	78.85
L3 × T4	11.49	9.01	10.25	85.47	76.46	80.97
L4 × T1	12.73	7.68	10.21	80.77	68.38	74.58
L4 × T2	11.58	7.88	9.73	88.77	72.35	80.56
L4 × T3	12.83	8.99	10.91	81.73	70.00	75.87
L4 × T4	12.77	8.45	10.61	86.47	69.19	77.83
L5 × T1	11.77	8.70	10.23	74.14	67.59	70.87
L5 × T2	12.02	9.78	10.90	85.92	76.67	81.29
L5 × T3	12.69	9.74	11.22	84.44	74.54	79.49
L5 × T4	11.29	9.93	10.61	82.85	68.62	75.73
L6 × T1	12.97	8.78	10.87	77.89	63.86	70.87
L6 × T2	11.96	8.19	10.07	87.19	69.77	78.48
L6 × T3	12.88	8.97	10.93	83.47	71.84	77.65
L6 × T4	12.87	9.16	11.02	81.77	71.08	76.42
L7 × T1	13.70	9.65	11.67	89.84	70.30	80.07
L7 × T2	13.17	10.29	11.73	84.38	75.61	79.99
L7 × T3	14.41	9.40	11.90	80.47	72.70	76.59
L7 × T4	13.60	10.57	12.09	83.58	70.82	77.20
L8 × T1	14.55	8.54	11.54	77.48	71.92	74.70
L8 × T2	13.96	8.69	11.33	87.51	72.42	79.97
L8 × T3	13.68	9.33	11.51	83.80	70.17	76.99
L8 × T4	13.91	9.99	11.95	84.64	70.86	77.75
L9 × T1	14.00	8.88	11.44	74.38	68.06	71.22
L9 × T2	13.50	8.97	11.23	85.58	71.36	78.47
L9 x T3	14.22	9.91	12.06	83.07	72.09	77.58
L9 × T4	13.57	8.78	11.17	86.99	70.41	78.70
L10 × T1	11.58	8.46	10.02	76.99	67.99	72.49
L10 × T2	10.87	8.81	9.84	89.61	74.44	82.03
L10 × T3	12.78	9.28	11.03	81.05	74.52	77.78
L10 × T4	12.29	10.31	11.30	85.48	73.33	79.41
Average hybrids	12.69	9.07	10.88	83.68	71.83	77.75
LSD 5%	0.26	0.29	0.20	2.77	3.40	2.29
LSD 1%	0.34	0.38	0.27	3.66	4.50	3.03

Table 4: Cont.

Genotype	1000-grain weight (g)			Grain yield per plant (g)		
	N	L	Comb.	N	L	Comb.
			Lines			
L1	41.60	37.44	39.52	31.30	17.45	24.38
L2	39.89	35.87	37.88	24.70	15.35	20.03
L3	40.17	38.25	39.21	23.66	20.54	22.10
L4	36.64	31.65	34.14	22.03	17.85	19.94
L5	41.69	36.59	39.14	20.03	14.85	17.44
L6	44.80	39.92	42.36	24.21	21.53	22.87
L7	39.48	33.89	36.68	22.66	19.62	21.14
L8	35.93	31.59	33.76	20.32	17.47	18.89
L9	50.16	46.59	48.37	26.36	24.09	25.22
L10	45.21	40.30	42.75	30.19	22.07	26.13
Average lines	42.04	37.77	39.90	25.54	19.17	22.36
			Testers			
T1	44.49	38.40	41.44	29.44	14.48	21.96
T2	45.10	41.51	43.30	31.19	22.03	26.61
T3	40.61	37.12	38.86	26.29	20.21	23.25
T4	42.82	39.62	41.22	25.14	20.88	23.01
Average testers	43.98	39.29	41.63	26.31	19.37	22.84
			Hybrids			
L1 × T1	45.38	40.90	43.14	33.03	17.31	25.17
L1 × T2	50.08	46.97	48.52	31.56	22.58	27.07
L1 × T3	48.25	37.50	42.88	27.74	18.45	23.09
L1 × T4	46.27	43.25	44.76	26.84	19.19	23.02
L2 × T1	40.38	35.35	37.86	24.54	13.61	19.07
L2 × T2	45.24	41.27	43.26	31.91	19.54	25.73
L2 × T3	47.14	41.79	44.47	23.40	15.67	19.54
L2 × T4	42.80	38.53	40.67	22.52	19.79	21.15
L3 × T1	46.17	42.68	44.43	25.91	18.55	22.23
L3 × T2	47.79	41.57	44.68	32.23	19.12	25.67
L3 × T3	38.22	33.29	35.76	22.09	20.07	21.08
L3 × T4	39.85	38.04	38.95	24.85	23.21	24.03
L4 × T1	37.62	32.82	35.22	26.02	17.62	21.82
L4 × T2	42.85	38.10	40.47	27.77	17.95	22.86
L4 × T3	38.32	32.69	35.51	24.16	21.81	22.98
L4 × T4	46.56	39.83	43.19	23.64	20.60	22.12
L5 × T1	50.68	34.83	42.75	27.30	14.21	20.76
L5 × T2	48.41	42.31	45.36	26.58	19.18	22.88
L5 × T3	42.57	39.74	41.15	27.87	17.36	22.62
L5 × T4	46.40	42.81	44.60	27.30	18.69	22.99
L6 × T1	51.15	37.18	44.16	27.40	20.76	24.08
L6 × T2	48.24	42.65	45.44	32.12	24.85	28.49
L6 × T3	42.73	38.25	40.49	23.34	19.37	21.36
L6 × T4	45.85	44.50	45.18	22.33	19.54	20.93
L7 × T1	40.64	35.79	38.22	28.95	17.92	23.43
L7 × T2	46.66	42.98	44.82	27.84	18.78	23.31
L7 × T3	45.77	41.74	43.75	24.36	17.82	21.09
L7 × T4	44.62	39.78	42.20	25.84	23.32	24.58
L8 × T1	42.84	38.85	40.85	28.55	15.66	22.10
L8 × T2	36.97	33.25	35.11	27.87	18.62	23.25
L8 × T3	41.67	37.33	39.50	22.66	17.46	20.06
L8 × T4	42.81	34.88	38.84	22.55	17.55	20.05
L9 × T1	47.47	44.64	46.05	27.61	24.90	26.26
L9 × T2	41.95	38.95	40.45	26.86	23.22	25.04
L9 x T3	48.29	43.94	46.11	24.53	22.06	23.30
L9 × T4	50.00	47.60	48.80	25.46	21.13	23.29
L10 × T1	48.39	45.28	46.83	29.58	16.71	23.14
L10 × T2	45.72	42.68	44.20	28.81	22.30	25.55
L10 × T3	41.92	38.57	40.24	24.53	23.56	24.05
L10 × T4	41.61	39.90	40.75	24.61	17.64	21.13
Average hybrids	44.66	39.83	42.24	26.58	19.44	23.01
LSD 5%	0.43	0.54	0.36	1.11	1.00	0.77
LSD 1%	0.57	0.72	0.48	1.47	1.32	1.02

For 1000-grain weight, the lowest mean value for lines were detected by Sids 13 (L8) (35.93 g, 31.59 g and 33.76 g) and the highest mean value were found by Sids 14 (L9) (50.16 g, 46.59 g and 48.37 g) under normal nitrogen, low nitrogen and combined data, respectively. The desirable mean value for testers were noted by Sids 12 (T2) under all conditions. The mean performance of F_1 hybrids for 1000-grain weight were ranged from 36.97 g for Sids 13 (L8) × Sids 12 (T2) to 51.15 g for Misr 1 (L6) × Gemmeiza 9 (T1), 32.68 g for Sakha 93 (L4) × Shandaweel 1 (T3) to 47.60 g for Sids 14 (L9) × Giza 168 (T4) and 35.11 g for Sids 13 (L8) × Sids 12 (T2) to 48.80 g for Sids 14 (L9) × Giza 168 (T4) under normal nitrogen, low nitrogen and combined data, respectively.

For grain yield per plant, the desirable mean value for lines found by Gemmeiza 7 (L1) (31.30 g) and Gemmeiza 12 (L10) (30.19 g) under normal nitrogen. Where under low nitrogen was Sids 14 (L9) (24.09 g) and under combined condition were Sids 14 (L9) (25.22 g) and Gemmeiza 12 (L10) (26.13 g). While, the lowest mean value for lines was found by Sakha 94 (L5) (20.03 g, 14.85 g and 17.44 g) under normal nitrogen, low nitrogen and their combined, respectively. The best mean value for testers were detected by Sids 12 (T2) were 31.19 g, 22.03 g and 26.61 g under normal nitrogen, low nitrogen and their combined, respectively. The average of F_1 hybrids were 26.58 g under normal nitrogen. They ranged from 33.03 g and 32.12 g for Gemmeiza 7 (L1) × Gemmeiza 9 (T1) and Misr 1 (L6) × Sids 12 (T2) respectively, to 22.09 g for Gemmeiza 11 (L3) × Shandaweel (T3). Under low nitrogen, fourteen hybrids founded over 20 g per plant. The hybrids ranged from 13.61 g for Gemmeiza 10 (L2) × Gemmeiza 9 (T1) to 24.90 g and 24.85 g for Sids 14 (L9) × Gemmeiza 9 (T1) and Misr1 (L6) × Sids 12 (T2), respectively. Under combined analysis, the mean F_1 hybrids ranged from 19.07 g for Gemmeiza 10 (L2) × Gemmeiza 9 (T1) to 28.49 g for Misr 1 (L6) × Sids 12 (T2). Generally, twenty-two hybrids from 40 F_1's were highly mean value for both of 1000- grain weight and grain yield per plant under low level of nitrogen fertilization. A lot of previously studies reported that high mean performance values for grain yield per plant under low level of nitrogen like, Koumber (2007), El-Refaey *et al.* (2009), Abdel Nour *et al.* (2011), Fellahi *et al.* (2013) Al-Naggar *et al.* (2015), Al-Naggar *et al.* (2016), Al-Naggar *et al.* (2017), El-Nahas *et al.* (2021) and Emam *et al.* (2021).

Combining ability effects

a. General combining ability (GCA) effects

General combining ability estimation for parents (line and testers) under two levels of nitrogen fertilization and their combined analysis for all studied traits are presented in Table 5.

For number of spikes per plant, Misr 2 (L7), Sids 13 (L8) and Sids 14 (L9) had significant and positive general combining ability for number of spikes per plant. The two testers Gemmeiza 9 (T1) and Shandweel 1 (T3) were positive significant GCA effect under normal level of nitrogen. Positive and significant general combining ability effect for number of spikes per plant were observed by Gemmeiza 11 (L3), Sakha 94 (L5), Misr 2 (L7) and Gemmeiza 12 (L10) under low level of nitrogen fertilization. In the same condition, Shandweel 1 (T3) and Giza 168 (T4) showed highly significant general combining ability. Under the combined condition, the parental Line 7, Line 8 and Line 9, also, the testers Shandweel 1 (T3) and Giza 168 (T4) were highly significant general combining ability effect, which were the best among the parental set as progenitors in breeding programs to improve this trait under such condition.

For number of grains per spike, Gemmeiza 10 (L2) was the only significant desirable line for number of grains per spike under normal fertilization. In the same condition, Gemmeiza 7 (L1), Gemmeiza 11 (L3), Sakha 93 (L4) and Misr 2 (L7) showed positive values but not significant general combining ability. The testers, Sids 12 (T2) and Giza 168 (T4) were highly significant for number of grains per spike. Only Gemmeiza 11(L3) was highly significant general combining ability effect under low nitrogen. Gemmeiza 7 (L1), Sakha 94 (L5), Misr 2 (L7) and Gemmeiza 12 (L10) showed positive values but not significant GCA effect. The tester Sids 12

Table 5: General combining ability (GCA) effects for parents (lines and testers) for all traits under normal nitrogen (N), low nitrogen (L) and their combined.

Parents	No. of spikes per plant			No. of grains per spike			1000-grain weight (g)			Grain yield per plant (g)		
	N	L	Comb.	N	L	Comb.	N	L	Comb.	N	L	Comb.
Lines												
Gemmeiza 7	0.06	-0.73**	-0.33**	0.85	0.93	0.89*	2.84**	2.33**	2.58**	3.22**	-0.06	1.58**
Gemmeiza 10	-0.63**	0.00	-0.31**	1.40**	-1.88**	-0.24	-0.76**	-0.59**	-0.68**	-0.99**	-2.29**	-1.64**
Gemmeiza 11	-1.16**	0.23**	-0.47**	0.94	6.04**	3.49**	-1.65**	-0.93**	-1.29**	-0.31	0.79**	0.24
Sakha 93	-0.21**	-0.82**	-0.52**	0.76	-1.85**	-0.55	-3.32**	-3.96**	-3.64**	-1.18**	0.05	-0.56**
Sakha 94	-0.74**	0.46**	-0.14**	-1.84**	0.02	-0.91	2.36**	0.10	1.23**	0.69**	-2.08**	-0.70**
Misr 1	-0.02	-0.30**	-0.16**	-1.10*	-2.69**	-1.90**	2.34**	0.82**	1.58**	-0.28	1.69**	0.70**
Misr 2	1.03**	0.90**	0.97**	0.89	0.53	0.71	-0.23**	0.25*	0.01	0.17	0.02	0.09
Sids 13	1.34**	0.06	0.28**	-0.32	-0.49	-0.16	-3.59**	-3.75**	-1.47**	-1.17**	-2.12**	-0.66**
Sids 14	1.14**	0.06	0.24**	-1.17*	-1.35*	-0.50	2.27**	3.96**	1.24**	-0.46*	3.39**	0.59**
Gemmeiza 12	-0.81**	0.14**	-0.13**	-0.39	0.74	0.07	-0.25**	1.78**	0.31**	0.30	0.61**	0.18
LSD 0.05 for line	0.09	0.10	0.07	0.98	1.20	0.81	0.15	0.19	0.13	0.39	0.35	0.27
LSD 0.01 for line	0.12	0.13	0.10	1.29	1.59	1.07	0.20	0.25	0.17	0.52	0.47	0.36
Testers												
Gemmeiza 9	0.13**	-0.46**	-0.16**	-4.74**	-1.72**	-3.23	0.41**	-0.99**	-0.29	1.31**	-1.72**	-0.20
Sids 12	-0.47**	-0.18**	-0.33**	3.99**	1.69**	2.84**	0.73**	1.25**	0.99**	2.78**	1.17**	1.98**
Shandaweel 1	0.41**	0.31**	0.36**	-0.57	0.73	0.08	-1.17**	-1.34**	-1.25	-2.11**	-0.08	-1.09**
Giza 168	-0.07*	0.33**	6.66**	1.32**	-0.70	4.69**	0.02	1.09**	2.59**	-1.98**	0.62**	13.13**
LSD 0.05 for tester	0.06	0.06	0.05	0.62	0.76	0.51	0.10	0.12	0.08	0.25	0.22	0.17
LSD 0.01 for tester	0.08	0.08	0.06	0.82	1.01	0.68	0.13	0.16	0.11	0.33	0.29	0.23

* and ** Significant at 0.05 and 0.01 probability levels, respectively.

(T2) showed highly significant for number of grains per spike. Under combined condition, two parental lines (Gemmeiza 7 (L1) and Gemmeiza 11 (L3)) and two testers (Sids 12 (T2) and Giza 168 (T4)) showed positive and significant general combining ability effect.

Desirable positive and significant general combining ability for 1000-grain weight were observed by Gemmeiza 7 (L1) (2.84), Sakha 94 (L5) (2.36), Misr 1 (L6) (2.34) and Sids 14 (L9) (2.27) under normal level of nitrogen fertilization. The testers, Gemmeiza 9 (T1) (0.41) and Sids 12 (T2) (0.73) showed positive and significant testers for 1000-grain weight. Positive and significant general combining ability for 1000-grain weight belonged to Gemmeiza 7 (L1) (2.33), Misr 1 (L6) (0.82), Misr 2 (L7) (0.25), Sids 14 (L9) (3.96) and Gemmeiza 12 (L10) (1.28). The testers, Sids 12 (T2) (1.25) and Giza 168 (T4) (1.09) showed that the positive and significant desirable trend under low level of nitrogen fertilization. The five lines, Gemmeiza 7 (L1) (2.58), Sakha 94 (L5) (1.23), Misr 1 L6 (1.58), Sids 14 (L9) (1.24) and Gemmeiza 12 (L10) (0.30) were the best desirable ones for general combining ability. The testers, Sids 12 (T2) (0.99) and Giza 168 (T4) (2.59) were showed positive and significant desirable trend under combined condition.

For grain yield per plant, Gemmeiza 7 (L1) (3.22) and Sakha 94 (L5) (0.69) obtained significant desirable general combining ability for grain yield per plant under normal condition. The testers, Gemmeiza 9 (T1) (1.31) and Sids 12 (T2) (2.78) were desirable tester for this trait. Positive and significant general combining ability for grain yield per plant were demonstrated by Gemmeiza 11(L3) (0.79), Misr 1 (L6) (1.69), Sids 14 (L9) (3.39) and Gemmeiza 12 (L10) (0.61) under low level of nitrogen fertilization. The desirable testers were Sids 12 (T2) (1.17) and Giza 168 (T4) (0.62). Gemmeiza 7 (L1) (1.58), Misr 1 (L6) (0.70) and Sids 14 (L9) (0.59) were the best desirable ones for general combining ability under combined condition. The two testers Sids 12 (T2) (1.98) and Giza 168 (T4) (13.13) had desirable trend and significant values for general combining ability, which indicated their superiority as promising prognitors for high yielding ability.

The results were similar to Soylu and Akgun (2007), Tabassum *et al.* (2017), Sarfraz *et al.* (2020), Kutlu and Sirel (2019), Din *et al.* (2021) and Fouad and Mohamed (2023).

b. Specific combining ability (SCA) effects

Estimation of specific combining ability SCA effects for all F1 hybrids under the two nitrogen levels and their combined are listed in Table 6.

For number of spikes per plant, desirable positive and significant specific combining ability effects were attained in Gemmeiza 7 × Gemmeiza 9 (0.34), Gemmeiza 7× Sids 12 (0.25), Gemmeiza 10 × Gemmeiza 9 (0.55), Gemmeiza 10 × Giza 168 (0.29), Gemmeiza 11 × Shandaweel (0.51), Sakha 93 × Giza 168 (0.36), Sakha 94 × Sids 12 (0.55), Sakha 94 × Shandaweel (0.34), Misr 1 × Giza 168 (0.27), Misr 2 × Shandaweel (0.28), Sids13 × Gemmeiza 9 (0.39), Sids13 × Sids 12 (0.41), Gemmeiza 12 × Shandaweel (0.49) and Gemmeiza 12 × Giza 168 (0.48) under normal nitrogen. Under low nitrogen, the hybrids Gemmeiza 7 × Sids 12 (0.27), Gemmeiza 7 × Shandaweel (0.26), Gemmeiza 10 × Gemmeiza 9 (0.25), Gemmeiza 10 × Shandaweel (0.35), Gemmeiza 11 × Gemmeiza 9 (0.43), Gemmeiza 11 × Sids 12 (0.25), Sakha 93 × Shandaweel (0.44), Sakha 94 × Sids 12 (0.42), Misr 1 × Gemmeiza 9 (0.46), Misr 2 × Sids 12 (0.49), Misr 2 × Giza 168 (0.27), Sids13 × Giza 168 (0.52), Sids14 × Gemmeiza 9 (0.21), Sids14 × Shandaweel (0.47) and Gemmeiza 12 × Giza 168 (0.77) were positive and significant SCA effects. The hybrids, Gemmeiza 7 × Sids 12 (0.26), Gemmeiza 10 × Gemmeiza 9 (0.40), Gemmeiza 11 × Sids 12 (0.22), Gemmeiza 11 × Shandaweel (0.22), Sakha 93 × Shandaweel (0.19), Sakha 94 × Sids 12 (0.49), Misr 1 × Gemmeiza 9 (0.31), Misr 1 × Giza 168 (0.16), Misr 2 × Sids 12 (0.21), Sids13 × Giza 168 (0.24), Sids14 × Shandaweel (0.23) and Gemmeiza 12 × Giza 168 (0.62) were positive and significant SCA effects under combined condition.

For number of grains per spike, desirable positive and significant specific combining ability effect were achieved by Gemmeiza 10 × Shandaweel (2.75), Gemmeiza 10 × Giza 168 (3.03), Gemmeiza 11 × Gemmeiza 9 (3.87), Sakha 94 × Shandaweel (3.17), Misr 2 × Gemmeiza 9 (10.01), Sids14 × Giza 168 (3.17) and Gemmeiza 12 × Sids 12 (2.34) under normal condition. Five hybrids, Gemmeiza 7 × Gemmeiza 9 (4.51), Gemmeiza 10 × Gemmeiza 9 (3.29), Gemmeiza 11 × Sids 12 (3.00), Sakha 94 × Sids 12 (3.13) and Misr 1 × Giza 168 (3.64) were highly significant for SCA effects under low nitrogen. Under combined analysis, seven hybrids were positive and significant SCA effects namely, Gemmeiza 7 × Gemmeiza 9 (2.45), Gemmeiza 11 × Gemmeiza 9 (1.84), Sakha 94 × Gemmeiza 9 (1.62), Sakha 94 × Shandaweel (2.56), Misr 1 × Shandaweel (1.72), Misr 2 × Gemmeiza 9 (4.84) and Sids14 × Giza 168 (1.90).

Table 6: Estimates of specific combining ability (SCA) effects for 40 F_1's in normal nitrogen (N), low nitrogen (L) and their combined for all studied traits.

crosses	No. of spikes per plant			No. of grains per spike		
	N	L	Comb.	N	L	Comb.
Gem. 7 × Gem. 9	0.34**	-0.55**	-0.10	0.40	4.51**	2.45**
Gem. 7 × Sids 12	0.25**	0.27**	0.26**	1.47	-4.35**	-1.44
Gem. 7 × Shandaweel	-0.02	0.26*	0.12	0.65	0.55	0.60
Gem. 7 × Giza 168	-0.57**	0.02	-0.28**	-2.53*	-0.71	-1.62*
Gem. 10 × Gem. 9	0.55**	0.25*	0.40**	-6.37**	3.29**	-1.54
Gem. 10 × Sids 12	-0.28**	-0.35**	-0.32**	0.60	-1.74	-0.57
Gem. 10 × Shandaweel	-0.56**	0.35**	-0.11	2.75**	-1.49	0.63
Gem. 10 × Giza 168	0.29**	-0.25*	0.02	3.03**	-0.06	1.48
Gem. 11 × Gem. 9	-0.72**	0.43**	-0.15*	3.87**	-0.20	1.84*
Gem. 11 × Sids 12	0.18	0.25*	0.22**	-0.55	3.00*	1.23
Gem.11 × Shandaweel	0.51**	-0.06	0.22**	-2.86**	-2.09	-2.48**
Gem. 11 × Giza 168	0.04	-0.62**	-0.29**	-0.46	-0.72	-0.59
Sakha 93 × Gem. 9	0.12	-0.11	0.01	1.08	0.12	0.60
Sakha 93 × Sids 12	-0.42**	-0.20	-0.31**	0.34	0.69	0.51
Sakha 93 × Shandaweel	-0.06	0.44**	0.19*	-2.13*	-0.71	-1.42
Sakha 93 × Giza 168	0.36**	-0.13	0.12	0.71	-0.09	0.31
Sakha 94 × Gem. 9	-0.31**	-0.38**	-0.34**	-2.95**	-2.55*	-2.75**
Sakha 94 × Sids 12	0.55**	0.42**	0.49**	0.09	3.13*	1.62*
Sakha 94 × Shandaweel	0.34**	-0.10	0.12	3.17**	1.95	2.56**
Sakha 94 × Giza 168	-0.59**	0.06	-0.26**	-0.31	-2.54*	-1.42
Misr 1 × Gem. 9	0.17	0.46**	0.31**	0.05	-3.56**	-1.76*
Misr 1 × Sids 12	-0.24*	-0.41**	-0.32**	0.63	-1.06	-0.21
Misr 1 × Shandaweel	-0.20*	-0.11	-0.15*	1.46	1.97	1.72*
Misr 1 × Giza 168	0.27**	0.06	0.16*	-2.13*	2.64*	0.26
Misr 2 × Gem. 9	-0.15	0.13	-0.01	10.01**	-0.34	4.84**
Misr 2 × Sids 12	-0.08	0.49**	0.21**	-4.18**	1.57	-1.31
Misr 2 × Shandaweel	0.28**	-0.88**	-0.30**	-3.52**	-0.39	-1.95*
Misr 2 × Giza 168	-0.05	0.27*	0.11	-2.31*	-0.84	-1.58*
Sids13 × Gem. 9	0.39**	-0.14	0.12	-1.14	2.29	0.58
Sids13 × Sids 12	0.41**	-0.27**	0.07	0.16	-0.61	-0.22
Sids13 × Shandaweel	-0.75**	-0.11	-0.43**	1.01	-1.90	-0.44
Sids13 × Giza 168	-0.05	0.52**	0.24**	-0.04	0.22	0.09
Sids14 × Gem. 9	0.05	0.21*	0.13	-3.38**	-0.70	-2.04*
Sids14 × Sids 12	0.15	0.01	0.08	-0.91	-0.81	-0.86
Sids14 × Shandaweel	-0.01	0.47**	0.23**	1.13	0.88	1.00
Sids14 × Giza 168	-0.18	-0.69**	-0.43**	3.17**	0.63	1.90*
Gem. 12 × Gem. 9	-0.43**	-0.30**	-0.37**	-1.55	-2.87*	-2.21
Gem. 12 × Sids 12	-0.53**	-0.23*	-0.38**	2.34*	0.18	1.26
Gem. 12 × Shandaweel	0.49**	-0.24*	0.12	-1.66	1.22	-0.22
Gem. 12 × Giza 168	0.48**	0.77**	0.62**	0.87	1.46	1.17
L.S.D. (Sij) 5%	0.18	0.20	0.14	1.96	2.41	1.62
L.S.D. (Sij) 1%	0.24	0.27	0.19	2.59	3.18	2.14
L.S.D. (Sij-ki) 5%	0.26	0.29	0.20	2.77	3.40	2.29

* and ** Significant at 0.05 and 0.01 probability levels, respectively.

Table 6: Cont.

crosses	1000-grain weight (g)			Grain yield per plant (g)		
	N	L	Comb.	N	L	Comb.
Gem. 7 × Gem. 9	-2.53**	-0.26	-1.39**	1.92**	-0.36	0.78**
Gem. 7 × Sids 12	1.85**	3.57**	2.71**	-1.01*	2.03**	0.51
Gem. 7 × Shandaweel	1.93**	-3.31**	-0.69**	0.05	-0.86*	-0.40
Gem. 7 × Giza 168	-1.25**	0.01	-0.62**	-0.97*	-0.82*	-0.89**
Gem. 10 × Gem. 9	-3.93**	-2.89**	-3.41**	-2.37**	-1.82**	-2.10**
Gem. 10 × Sids 12	0.62**	0.79**	0.70**	3.54**	1.22**	2.38**
Gem. 10 × Shandaweel	4.42**	3.90**	4.16**	-0.08	-1.40**	-0.74**
Gem. 10 × Giza 168	-1.11**	-1.79**	-1.45**	-1.09**	2.01**	0.46
Gem. 11 × Gem. 9	2.74**	4.78**	3.76**	-1.67**	0.03	-0.82**
Gem. 11 × Sids 12	4.05**	1.43**	2.74**	3.18**	-2.29**	0.45
Gem.11 × Shandaweel	-3.62**	-4.27**	-3.94**	-2.07**	-0.09	-1.08**
Gem. 11 × Giza 168	-3.18**	-1.94**	-2.56**	0.57	2.35**	1.46**
Sakha 93 × Gem. 9	-4.13**	-2.04**	-3.09**	-0.69	-0.16	-0.43
Sakha 93 × Sids 12	0.78**	0.99**	0.88**	-0.40	-2.71**	-1.56**
Sakha 93 × Shandaweel	-1.85**	-1.83**	-1.84**	0.87*	2.39**	1.63**
Sakha 93 × Giza 168	5.20**	2.88**	4.04**	0.23	0.48	0.35
Sakha 94 × Gem. 9	3.25**	-4.10**	-0.43**	-1.27**	-1.43**	-1.35**
Sakha 94 × Sids 12	0.66**	1.14**	0.90**	-3.46**	0.64	-1.41**
Sakha 94 × Shandaweel	-3.28**	1.16**	-1.06**	2.72**	0.08	1.40**
Sakha 94 × Giza 168	-0.63**	1.80**	0.58**	2.02**	0.71*	1.36**
Misr 1 × Gem. 9	3.74**	-2.47**	0.63**	-0.21	1.35**	0.57*
Misr 1 × Sids 12	0.51**	0.76**	0.63**	3.05**	2.55**	2.80**
Misr 1 × Shandaweel	-3.09**	-1.05**	-2.07**	-0.85*	-1.68**	-1.26**
Misr 1 × Giza 168	-1.16**	2.77**	0.80**	-1.99**	-2.22**	-2.10**
Misr 2 × Gem. 9	-4.19**	-3.29**	-3.74**	0.89*	0.18	0.53
Misr 2 × Sids 12	1.51**	1.66**	1.58**	-1.69**	-1.85**	-1.77**
Misr 2 × Shandaweel	2.51**	3.01**	2.76**	-0.28	-1.56**	-0.92**
Misr 2 × Giza 168	0.18	-1.37**	-0.60**	1.07**	3.24**	2.16**
Sids13 × Gem. 9	1.35**	3.77**	2.56**	1.83**	0.05	0.94**
Sids13 × Sids 12	-4.84**	-4.08**	-4.46**	-0.32	0.12	-0.10
Sids13 × Shandaweel	1.77**	2.60**	2.18**	-0.64	0.22	-0.21
Sids13 × Giza 168	1.72**	-2.29**	-0.29*	-0.87*	-0.40	-0.64*
Sids14 × Gem. 9	0.13	1.85**	0.99**	0.18	3.79**	1.99**
Sids14 × Sids 12	-5.71**	-6.07**	-5.89**	-2.03**	-0.78*	-1.41**
Sids14 × Shandaweel	2.53**	1.50**	2.01**	0.52	-0.69	-0.08
Sids14 × Giza 168	3.05**	2.73**	2.89**	1.32**	-2.32**	-0.50
Gem. 12 × Gem. 9	3.57**	4.67**	4.12**	1.39**	-1.63**	-0.12
Gem. 12 × Sids 12	0.58**	-0.18	0.20	-0.85*	1.07**	0.11
Gem. 12 × Shandaweel	-1.32**	-1.70**	-1.51**	-0.24	3.59**	1.67**
Gem. 12 × Giza 168	-2.82**	-2.79**	-2.81**	-0.29	-3.03**	-1.66**
L.S.D. (Sij) 5%	0.30	0.38	0.26	0.79	0.70	0.54
L.S.D. (Sij) 1%	0.40	0.51	0.34	1.04	0.93	0.72
L.S.D. (Sij-ki) 5%	0.43	0.54	0.36	1.11	1.00	0.77

* and ** Significant at 0.05 and 0.01 probability levels, respectively.

For 1000-grain weight, sixteen-hybrid had positive and significant specific combining ability effects for 1000-grain weight under normal nitrogen, low nitrogen and their combined. In addition, Gemmeiza 7 × Shandaweel (1.93), Sakha 94 × Gemmeiza 9 (3.25), Misr 1 × Gemmeiza 9 (3.74), Sids13 × Giza 168 (1.72) and Gemmeiza 12 × Sids 12 (0.58) were significant SCA effects under normal nitrogen. Sakha 94 × Shandaweel (1.16), Misr 1 × Giza 168 (2.77) and Sids14 × Gemmeiza 9 (1.85) were desirable SCA effects under low nitrogen. Also, Sakha 94 × Giza 168 (0.58), Misr 1 × Gemmeiza 9 (0.63), Misr 1 × Giza 168 (0.80) and Sids14 × Gemmeiza 9 (0.99) under combined analysis.

For grain yield per plant, desirable positive and significant SCA effects showed in Gemmeiza 7 × Gemmeiza 9 (1.92), Gemmeiza 10 × Sids 12 (3.54), Gemmeiza 11 × Sids 12 (3.18), Sakha 93 × Shandaweel (0.87), Sakha 94 × Shandaweel (2.72), Sakha 94 × Giza 168 (2.02), Misr 1 × Shandaweel (3.05), Misr 2 × Gemmeiza 9 (0.89), Misr 2 × Giza 168 (1.07), Sids13 × Gemmeiza 9 (1.83), Sids14 × Giza 168 (1.32) and Gemmeiza 12 × Gemmeiza 9 (1.39) under normal nitrogen. The hybrids, Gemmeiza 7 × Sids 12 (2.03), Gemmeiza 10 × Sids 12 (1.22), Gemmeiza 10 × Giza 168 (2.01), Gemmeiza 11 × Giza 168 (2.35), Sakha 93 × Shandaweel (2.39), Sakha 94 × Giza 168 (0.71), Misr 1 × Gemmeiza 9 (1.35), Misr 1 × Sids 12 (2.55), Misr 2 × Giza 168 (3.24), Sids14 × Gemmeiza 9 (3.79), Gemmeiza 12 × Sids 12 (1.07) and Gemmeiza 12 × Shandaweel (3.59) showed positive and significant SCA effects under low nitrogen. Under combined condition, Gemmeiza 7 × Gemmeiza 9 (0.78), Gemmeiza 10 × Sids 12 (2.38), Gemmeiza 11 × Giza 168 (1.46), Sakha 93 × Shandaweel (1.63), Sakha 94 × Shandaweel (1.40), Sakha 94 × Giza 168 (1.36), Misr 1 × Gemmeiza 9 (0.57), Misr 1 × Sids 12 (2.80), Misr 2 × Giza 168 (2.16), Sids13 × Gemmeiza 9 (0.94), Sids14 × Gemmeiza 9 (1.99) and Gemmeiza 12 × Shandaweel (1.67) had positive and significant specific combining ability effects for grain yield per plant. In such hybrid combinations, desirable transgressive segregates could be expected in subsequent segregating generations. Therefore, these hybrids are valuable in wheat breeding programs for improving grain yield under low nitrogen level. These results are in agreement with the earlier studies carried out by Koumber (2007), Abdel-Nour *et al.* (2011), Fellahi *et al.* (2013), Aslam *et al.* (2014), Dedaniya *et al.* (2019) and El Nahas *et al.* (2021).

Genetic component

Table 7 cleared that specific combining ability effects played the major role in controlling the inheritance of all traits under nitrogen fertilizer levels. Where the general combining ability effects were less as compared to specific combining ability it means that there was presence of non-additive genetic action therefore hybrid breeding will be explained by these traits.

Ratio of GSA/SCA variances for the all studied traits were less than unity at both of nitrogen levels. Such result indicates that inheritance of these traits was mainly controlled by non-additive gene effects under such conditions of nitrogen fertilization. The preponderance of non-additive type of gene actions clearly indicated that selection of superior plants should be postponed to later generation. These results are supported findings of El-Refaey *et al.* (2009), Murugan and Kannan (2017), Fellah *et al.* (2013) and Emam *et al.* (2021).

The mean square due to SCA × N was higher in magnitude than those due to GCA × N for all traits studied, suggesting that SCA is more affected by nitrogen fertilizer than GCA for all traits. Similar results were showed by El-Nahas *et al.* (2021).

The efficiency of the selection is related with the size of narrow sense heritability in the segregating populations. The results of heritability in brood and narrow sense under two levels of nitrogen and their combined are showed in Table 7. Heritability value in brood sense were larger than the corresponding values of narrow sense for all traits under two levels of nitrogen fertilization. Moderate to low narrow sense heritability estimates were given for all traits studied under two nitrogen levels, indicating that most of the genetic variances may be due to non-additive genetic effect and the selection must be applied in the further generations. Similar results were reported by Al-Naggar *et al.* (2015), El-Nahas *et al.* (2021), Kumar *et al.* (2022) and Fouad and Mohamed (2023).

Table 7: Genetic components, heritability and proportional contribution for all traits in normal nitrogen (N), low nitrogen (L) and their combined.

Source	No. of spikes per plant			No. of grains per spike			1000-grain weight (g)			Grain yield per plant (g)		
	N	L	Comb.	N	L	Comb.	N	L	Comb.	N	L	Comb.
σ^2 gca	0.04	0.01	0.10	0.40	0.27	3.26	0.11	0.18	1.86	0.24	0.14	2.37
σ^2 sca	0.19	0.19	0.26	9.96	4.05	9.01	11.93	11.18	9.42	3.59	4.43	2.70
gca/sca	0.19	0.07	2.69	0.04	0.06	2.76	0.01	0.02	0.20	0.07	0.03	1.14
σ^2 gca $\times$ N			0.18			1.97			0.042			2.885
σ^2sca $\times$ N			0.19			7.48			4.278			3.277
H^2 (broad sense) %	91.30	87.53	95.71	78.66	51.02	85.29	99.43	99.03	99.31	89.62	92.56	94.81
H^2(narrow sense) %	25.68	11.70	18.69	5.85	6.14	5.99	1.72	3.12	2.42	10.70	5.47	8.08
σ^2 A	0.07	0.03	0.10	0.80	0.55	3.26	0.21	0.36	3.73	0.48	0.27	2.37
σ^2 D	0.19	0.19	0.54	9.96	4.05	18.02	11.93	11.17	9.41	3.59	4.42	5.40
Average degree of dominance ($\bar{a}$)	2.26	3.60	0.61	4.98	3.82	0.60	10.64	7.83	2.25	3.84	5.64	0.94
	Proportional contribution to the total variation											
Due to lines	74.75	49.36	65.26	5.99	50.07	21.62	37.49	38.47	41.21	17.72	40.85	27.54
Due to testers	10.85	22.78	17.19	54.33	15.65	50.12	3.78	9.48	6.09	52.43	16.42	33.26
Due to lines $\times$ testers	14.40	27.86	17.55	39.69	34.27	28.25	58.73	52.05	52.70	29.85	42.72	39.20

Value was obtained for the average degree of dominance (a) mean that the presence of over dominance, where greater than unity for all traits under the two levels of nitrogen fertilization.

Dominance variance (σ^2 D) was greater than additive variance (σ^2 A) in all traits studied under the two levels of nitrogen fertilization. These results indicated that non-additive type of gene action was the most prevalent in the genetic component for these traits under the two levels of nitrogen fertilization.

The proportional contribution of lines (females), testers (males) and their interaction (crosses) to total variance for different traits in F_1 hybrids revealed that maximum contribution to total variance of most traits were made by female lines under the two levels of nitrogen fertilization. Similar results were obtained by Akbar *et al.* (2009), Abdel-Nour *et al.* (2011) and Din *et al.* (2021).

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القدرة علي التآلف للمحصول ومكوناته في قمح الخبز تحت معدلات مختلفة من التسميد الآزوتي بإستخدام تحليل سلالة × كشاف

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الملخص العربي

أجري هذا البحث بمزرعة مركز البحوث الزراعية بالجميزة بهدف دراسة أهمية كل من القدرتين العامة والخاصة علي الإئتلاف للمحصول ومكوناته ، تقدير كلا من الفعل الجيني المضيف والسيادي والكفاءة الوراثية تحت مستويين من التسميد الأزوتي والتحليل المشترك لهما. وقد إستخدام ١٤ صنف من قمح الخبز لهذه الدراسة من خلال تحليل السلالة × كشاف ، حيث تم التهجين بين ١٠ أصناف من قمح الخبز (أمهات) مع ٤ كشافات (آباء) من خلال تحليل السلالة × كشاف تبعاً لكمبثرون (1957) في الموسم الأول ٢٠١٣/٢٠١٤م ، وفي الموسم الثاني ٢٠١٤/٢٠١٥م تم زراعة الآباء (١٠ سلالات و ٤ كشافات) مع ٤٠ هجين الناتجين من الموسم السابق في تجربتين منفصلتين لتقييمهم تحت مستويين من التسميد الأزوتي (٤٠كجم ، ٨٠ كجم أزوت /فدان). هذا وقد صممت كل من التجربتان في تصميم قطاعات كاملة العشوائية في ثلاث مكررات. وتم دراسة صفات عدد السنابل للنبات ، عدد الحبوب في السنبلة ، وزن ١٠٠٠حبة ، محصول النبات الفردي (جم).

وتتلخيص أهم النتائج فيما يلي:

أدي إستخدام المستوي المنخفض من التسميد الأزوتي (٤٠كجم ازوت/فدان) إلي إنخفاض متوسطات التراكيب الوراثية المختلفة لكل الصفات المدروسة. ظهر تباين القدرة العامة والخاصة علي التآلف معنوياً لجميع الصفات المدروسة تحت مستويي التسميد والتحليل المشترك لهما مما يوضح أهمية الفعل الجيني المضيف وغير المضيف في وراثة هذه الصفات. أظهر صنف القمح جميزة ١١ و جميزة ١٢ ومصر١ قدرة عامة عالية علي التآلف لمعظم الصفات المدروسة وذلك تحت التسميد الأزوتي المنخفض. وقد تم الحصول علي أفضل التأثيرات المرغوبة للقدرة الخاصة علي التآلف في أثني عشر هجين. تراوحت قيم معامل التوريث بالمعني الضيق من المتوسط إلي الأقل لكل الصفات المدروسة تحت مستويي التسميد الأزوتي والتحليل المشترك لهما. لذا يجب الإهتمام بالأباء والهجن سابقة الذكر عند التربية لإنتاج أصناف تتحمل مستويات منخفضة من التسميد الأزوتي.